Prepared for:

USAID-SARI/Energy Program

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Energy Security of Supply in India

May 2003

Nexant

Griffin House, 1st Floor South, 161 Hammersmith Road, London W6 8BS
Telephone: +44 20 7950 1600 Facsimile: +44 20 7950 1550
www.nexant.com

Final Report

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I Executive Summary

Overview

OVERALL ENERGY DEMAND

India's appetite for energy is strong. Its energy needs are going to increase by 50 per cent in the next 10 years to meet the demands of a burgeoning population and rapid economic growth. Estimates indicate that India needs a capacity addition of 60,700 MW between 2007 and 2012. It will need more fuel - oil, gas, coal - to generate this additional energy.

Meeting these demands presents several challenges. Will India's indigenous energy resources be sufficient? If not, what are the implications of importing energy resources? Will the country's infrastructure, already struggling to cope, be able to distribute energy to homes, plants, factories and farms? Does it have sufficient domestic investment to make sure the energy sector keeps up with demand during the next decade?

Our research shows that India lacks long term sources of energy that will ensure security as the gap between demand and existing energy supplies is set to widen over the next decade. As India consumes more energy, certain consequences follow: for example, it will need more oil, leading to greater dependence on Middle East oil imports with the attendant price uncertainty and depletion of foreign exchange.

India will also need more gas. The indigenous gas reserves have been recently boosted by new gas finds in Krishna Godavari although this will do no more than steady existing gas production as existing resources will begin to diminish rapidly as demand increases. Moreover, even if gas resources were sufficient, India lacks adequate pipelines and terminals to get gas to the consumer. Inevitably the gap between demand and supply will have to be met by gas imports.

Overview

OVERALL ENERGY DEMAND (continued)

After resources comes the question of supply. Power cuts are a fact of life - the consequence of a mismanaged power sector in arrears owing to decisions taken on the basis of political expediency rather than economic sense. A radical reform of the power sector, eliminating government interference, is required to ensure the investment in infrastructure and human resources necessary to give security of power supply.

Failure to meet its energy needs will impact India's economic growth. As one of the fastest growing economies in the world, energy is vital for India if it hopes to achieve its targets. These growth rates in turn are important if India is to provide jobs for the millions who will be surging onto the jobs market in the next few years.

This executive summary outlines the four main issues that have emerged from our report:

1. Securing the fuel and energy resources India needs
2. Expanding infrastructure to cope
3. Reforming the power sector
4. Fine-tuning government policy

Oil security risks are price related rather than physical supply disruptions

1. SECURING THE FUEL RESOURCES INDIA NEEDS

Relying on domestic energy sources does not necessarily translate into energy security. Nor do imports automatically suggest lack of security. Rather, diversity and flexibility of supply are essential. It does not matter which part of the world supplies come from or what mix of indigenous and imported fuels are used as long as supply is assured. A country's energy supplies are secure when they are not vulnerable to physical disruption, erratic fluctuations in price and availability or to environmental risks caused by, say, oil leaks or greenhouse gas emissions.

Reducing Vulnerability Over Oil Supplies

India's oil insecurity is not based on the fear of oil supplies drying up but the volatility of prices and greater dependency on imported oil as its need for oil goes up. Almost two-thirds of India's oil requirements are met by imports, partly the result of higher demand and partly because its oil industry has been unable to produce more oil. By 2010, imports may account for 80 per cent of total consumption.

Some options that India can explore are to diversify its oil imports by looking beyond the Middle East to countries such as Malaysia, Indonesia, Egypt or Russia. Since the global oil industry is volatile, it could also invest in equity stakes in oil fields overseas to give itself a natural hedge against volatility; ONGC is already doing this. In the short run, the government needs to establish larger oil reserves so that it can cope with any sudden crises or shortage. At present, India has an operational reserve of only 30 days (and plans to expand it to 45 days). For a sense of even greater security, India should look at improving its own domestic supply by encouraging exploration by multinationals.

Gas security will be provided by imports – Coal production by investment

Bridging the Gap Between Gas Supply and Demand

The demand for gas will exceed the forecast supply. The shortfall is estimated to grow to more than 30 bcm by 2011 if the current production level is maintained, including production from the newly discovered Krishna Godavari gas field (with estimated annual production of 9 bcm). Additional sources of supply will be needed to meet the forecasted demand.

In the short term, the growing imbalance between supply and demand will have to be met with LNG imports. The region surrounding India possesses generous gas supplies but lacks the massive amounts of capital needed for the requisite infrastructure of pipelines. Increased foreign investment in infrastructure will be possible only if the energy sector becomes more commercially appealing.

Expanding Coal Production

India is generously endowed with coal reserves, which currently provides 56 per cent of India's primary energy. No coal shortage is likely but the quality of coal is poor and levels of production need to increase. Coal reserves can meet the projected demand but, in its current condition, the coal industry can not simply extract and process the coal in sufficient quantities. Over the past 10 years, production has increased at only 3% per annum, and stood at 343 million tonnes in 2001. The major reason for this slow growth is a lack of investment resulting in the use of dated technology. Few mines employ advanced mining techniques, in fact a great many are still unmechanized.

Transporting coal to India's demand centres is a huge problem as most of the coal reserves are located far from the major markets – almost 40% is transported to power plants over 900 km away. Coal transportation is dependent upon a neglected and over-burdened rail system. Moreover, moving coal by rail is expensive due to cross subsidies between freight tariffs and passenger fares.

More coal production and better quality coal are only likely if the government reforms the coal sector sufficiently to attract private investment. Such investment is vital. If this does not happen, the country's power needs will have to be met with higher levels of imported coal than, for example, the 18 million tonnes it imported in 1999.

Investment in infrastructure will be important

2. EXPANDING INDIA'S INFRASTRUCTURE TO COPE

India's current infrastructure – railways, ports and pipelines - cannot meet the demand that extra energy imports will impose over the next 10 years. It will require substantial investment and expansion to cope. Since India lacks the necessary capital, it will need to look for foreign investment. Whether this comes or not will depend upon India's ability to successfully reform the energy sector to make it more commercially appealing than it is at present.

Infrastructure in the energy sector is particularly important owing to an imbalance between the location of energy sources in India and their markets, and the distances between importing locations and demand centres are prodigious. Given that India will be importing more crude oil and natural gas in future, it will need better ports and pipelines. The existing marine facilities are already struggling to cope with current volumes. More imports will impose further strain.

Power sector reform will be a prerequisite to ensuring reasonable supply

3. REFORMING THE POWER SECTOR

India enjoys no security of supply in the power sector. Much of the country is afflicted with power shortages at peak times. Most of the state-run state electricity boards are insolvent – partly because local politicians force them to supply free or heavily subsidised power – and therefore scare away private investors. Inadequate investment has greatly damaged the power sector. Wholesale reform of the power sector has been much talked about for the past decade but not enough has been done to put it on a commercial footing.

The combination of uneconomic tariffs, T&D losses of over 40 per cent, numerous cross-subsidies and simple theft have resulted in colossal arrears for most state electricity boards. Consequently they have no funds for improving the system. It will be difficult for India to enjoy energy security of supply without a radical restructuring of the boards; they need to be privatised, tariffs need to be drastically revised and an independent regulator should be established. Commercial pricing will also result in more efficient energy use and put downward pressure on demand.

Government has a major policy role in ensuring security of supply

4. FINE-TUNING GOVERNMENT POLICY

The government's role in providing energy security should be to define the acceptable level of risk, encourage investment and trade, and ensure effective regulation and efficient markets. Energy security is about minimising risks, not maximising domestic supply which, in India's case, could mean over-burdening already tired infrastructure.

India does not have sufficient domestic capital to finance the needs of the energy sector over the coming decades. The natural corollary is foreign investment but the country's ability to attract investors hinges on the success of power sector reforms. Investors will remain reluctant while state electricity boards remain insolvent. Making the whole sector more attractive by putting it on a commercial footing is the government's primary challenge.

In more general terms, energy planning is marred by lack of coordination. The various ministries involved – coal, power, petroleum and natural gas – need to work more closely in energy planning in order to optimise energy provision. The key to security of energy supply is the optimisation of all energy sources in order to balance economic costs against security risks. This becomes even more important in light of India's greater dependence on imports and need for massive capital investment.

II Introduction

India's energy requirements are set to increase. Regional trade can bring diversity and therefore increase the security of energy supply.

BACKGROUND

Energy has a major role to play in the Indian economy with a total consumption of 314 million toe, albeit the present consumption is relatively low at 20,000 Btu per 1 dollar of GDP. In the context of predicted economic growth of 5% for the year 2002 and similar thereafter in the medium-term, the nature of the domestic supply, both as primary energy (coal, oil, gas and hydro) and electricity (including related infrastructure) are important issues in defining the extent to which domestic resources can meet the growing energy demand.

PURPOSE

The purpose of this paper is to estimate the potential gap between demand and supply in the energy sectors and to assess India's options and ability to fill the gap. The time horizon is 10 years.

There are several regional trade possibilities from the SARI region as well as adjacent countries which can impact the security of supply in India. The commercial and policy issues that underpin the successful development of such large projects are significant.

Security of supply issues in the Indian energy sector, i.e. the main risks and measures to promote security as well as the effects of the supply disruptions and price volatility on the security of supply, are part of this study.

This paper addresses the ways of meeting the supply/demand gap and potential threats of supply disruption associated with the sources of energy supply and the infrastructure through which the energy is delivered

Risks associated with the sources of energy supply and the associated infrastructure for its delivery:

- Short-term supply availability versus **long-term adequacy of supply and the infrastructure** for delivering this supply to markets
- Operational security versus **strategic security** (i.e. failure of major supply sources and facilities)

This paper addresses the adequacy of long-term supply (next ten years) and related infrastructure and possibilities for creating strategic security of supply.

As a result, this paper highlights:

- ***What are the potential gaps in meeting energy demand;***
- ***What potential long-term energy supply options exist in the region;***
- ***What are the main security of supply risks in the region and how can they be mitigated.***

Having analysed energy supply and demand, the study identifies energy security of supply issues and the impact of regional trade on the security of supply

ENERGY SUPPLY

- By type, location and size
- Power generation capacity by fuel type and location
- Energy supply issues: reserves, cost of supply, pricing

ENERGY DEMAND

- Energy demand issues: pricing and non-payment
- By fuel type, usage profile and location
- Capacity and financial health of SEB's to invest

ENERGY SUPPLY/ DEMAND BALANCE

SECURITY OF SUPPLY

- Diversity of supply
- Measures to promote security
- Price volatility

REGIONAL TRADE TO ALLEVIATE SECURITY OF SUPPLY

- Imported energy sources pipeline and LNG
- Potential gas supplies from SARI and adjacent countries
- Commercial and regulatory issues
- Impact of regional cooperation

HOW CAN INFRASTRUCTURE COPE?

- Oil and gas infrastructure
- Electricity transmission systems
- Downstream
- Rail
- Imports and shipping

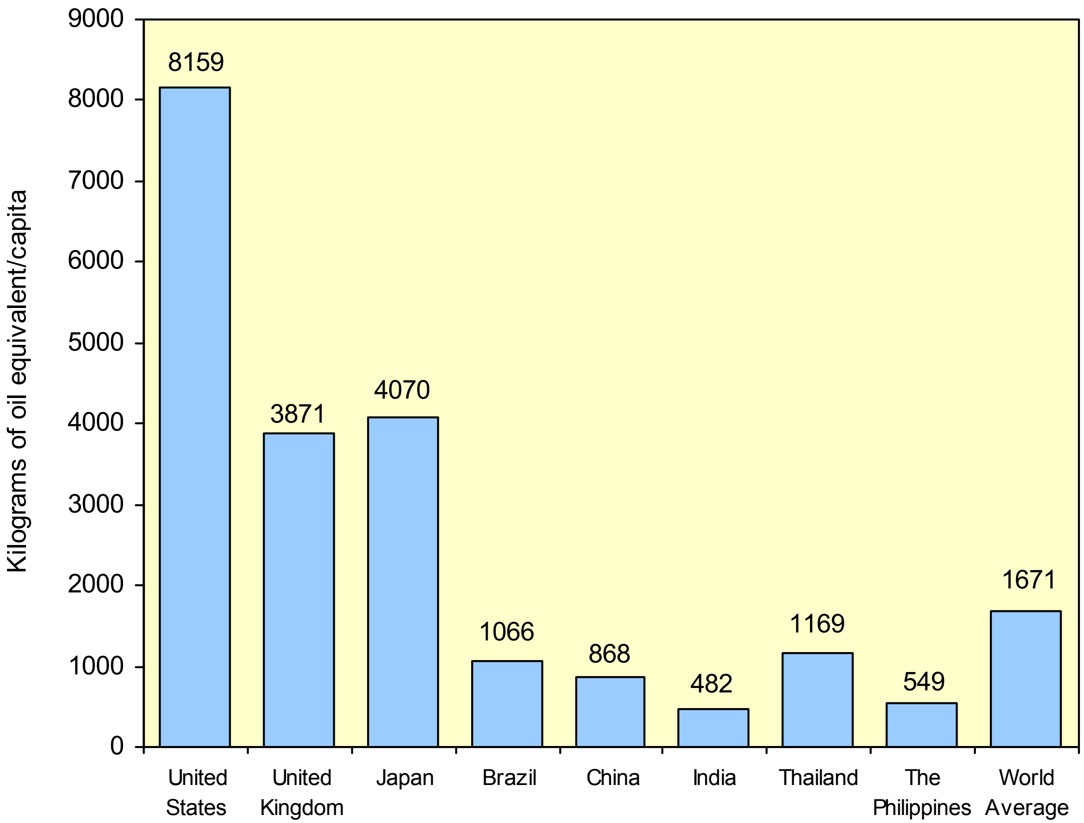
POLICIES TO SUPPORT REGIONAL ENERGY SOURCES

- Energy planning coordination and integration
- Governments encouragements of investments and trade
- Effective regulation

III Energy Sector Overview

India overall has insufficient primary energy sources to meet the growing domestic demand.

COMPARISON OF PER CAPITA ENERGY CONSUMPTION OF COUNTRIES - 1999



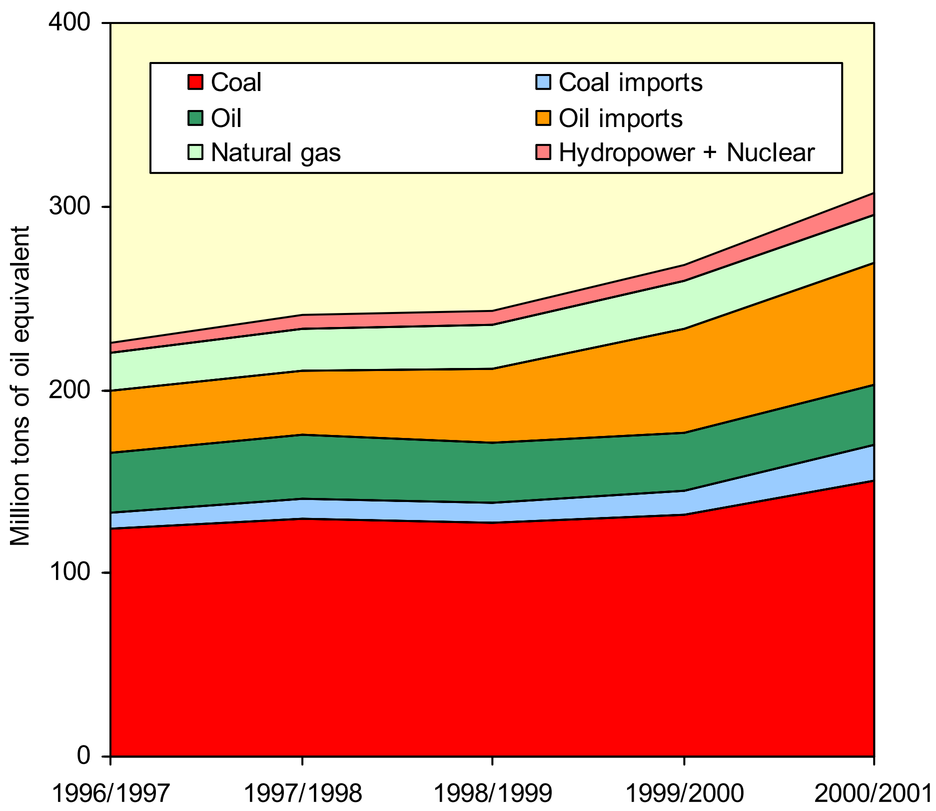
Source: The World Bank (2002)

Overall Energy Industry Overview

- India is a large country with the world's second largest population, now in excess of 1 billion people. Although total energy consumption is substantial at over 314 million tonnes of oil equivalent (toe), on a per capita basis energy consumption is India is very low, at less than a quarter of the world average and 5-10% of developed countries such as USA and Japan.
- India is projected to be one of the fastest growing economies. Concomitant with economic growth (estimated by the Indian Government at 7-8% over the next two decades), the country is already experiencing growth in energy demand. Providing energy supply is critical to sustaining economic growth.
- Overall, India is currently producing around 86% of its energy needs. This share has decreased over the last ten years from 92%. This trend signals the need to boost domestic energy supply through increased exploration, production, refining and the development of new transport infrastructure.

Primary energy consumption is dominated by coal.

INDIA'S ENERGY CONSUMPTION PATTERN



Source: TERI (2000)

Coal

- Coal production increased by 2.6 % in 2001 from the previous year, reaching 161 million toe, or 343 million tonnes
- While India exports a small amount of coal to nearby countries, it has evolved into a significant importer of coal as economic growth and domestic supply bottleneck have stimulated Indian demand for imported coal. India imported 18 million tonnes in 1999, mostly coking coal, or 6% of its coal needs.

Oil

- Oil production has been fairly stable since 1995. Production in 2001 was 36 million tonnes, or 782,000 barrels per day.
- India imports about 1.3 million barrels of crude oil per day, or almost two thirds of its crude oil requirements.

Natural Gas

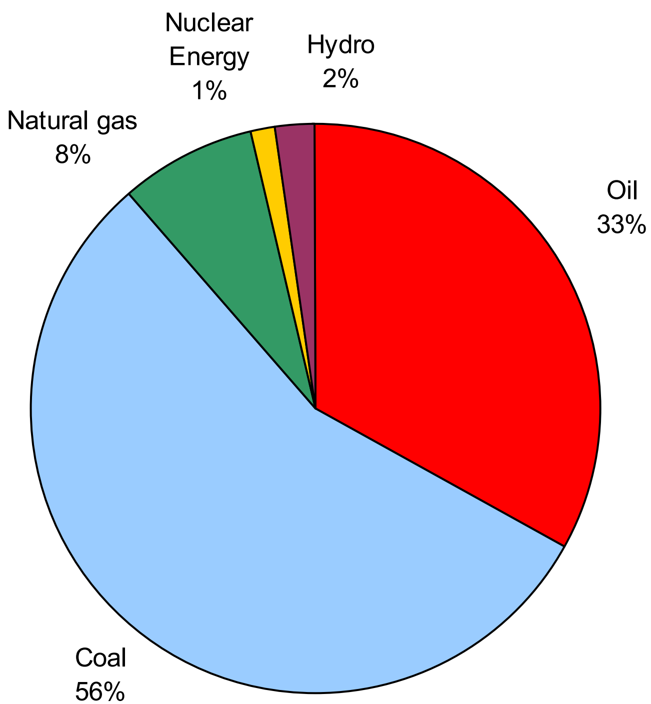
- Natural gas represents a growing component of the primary energy mix. In 2001, gas production reached 26 bcm or 23 million toe.

Hydro and Nuclear

- Hydropower and nuclear have been contributing with a minority share of the energy mix (up to 4%).

India has insufficient primary energy sources to meet the growing domestic demand.

PRIMARY ENERGY MIX – INDIA 2000



Source: Teri 2000-2001

Primary Energy

- The primary energy mix of India is approximately 56% coal, 33% oil, 8% natural gas, with nuclear and hydropower combined taking a 3% share.
- The primary indigenous energy source is provided by coal, India being the third largest coal producer with 7% of world reserves. Current proven coal reserves are 82 billion tonnes, which are sufficient to last around 200 years at the current level of production (2001) of around 343 million tonnes per year.
- Proven hydrocarbon reserves have declined over the last decade. These are placed at 730 million tonnes of crude oil and 660 bcm of natural gas. Recent discoveries in Krishna Godavari could increase this by 20 bcm, but the reserves have to be confirmed.

Energy Conversion

- The petroleum product supply has seen a boost since 1999 with new refinery capacity (10 million tonnes by end of 2002) added to the system.
- Total installed power generation capacity is 100GW, 71% of which is generated by coal, 25% from hydro, 3% from nuclear and 1% from wind.
- Captive power generation is estimated at nearly 15% of total installed capacity, i.e. 15 GW (TERI 2001)

IV Current Energy Supply

Domestic crude oil is supplied extensively by offshore fields.

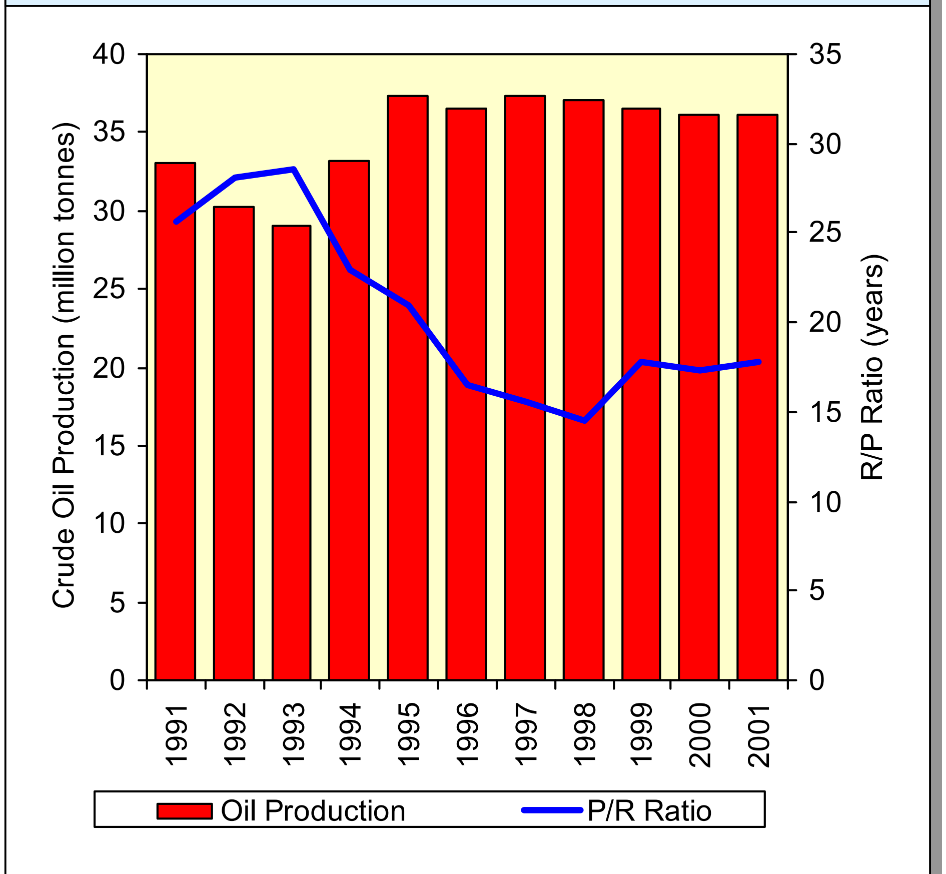
OIL PRODUCING REGIONS OF INDIA

Source: Nexant

- Oil and gas were first discovered in India in 1886, with a non-commercial oil well in Upper Assam.
- India's first serious push in oil and gas exploration came in the late 1950s. Oil and gas were discovered in the onshore Cambay basin, Gujarat in 1958. Exploration of the western offshore basin area off Bombay began in 1964 and in 1974 the massive Bombay High field was discovered.
- The bulk of India's domestic crude oil production comes from the west of the country – 55% from offshore fields and 18% from Gujarat onshore fields. The other significant producing area is Assam/Nagaland in the north east, produces 16% of the nation's crude oil.
- Domestic crude supply is thus heavily geographically constrained to the west of the country.

Domestic crude oil production has reached a plateau over the last ten years.

DOMESTIC CRUDE OIL PRODUCTION VERSUS RESERVES



Source: BP Statistical Review of World Energy 2002

- Total domestic crude oil production in year 2000 reached 36.2 million tonnes.
- Domestic crude oil production in India has been steady at around 35 million tonnes per annum over the last ten years despite no significant addition to reserves.
- Crude oil proved reserves in India were 600 million tonnes in 2000. The R/P ratio is 17 years.
- Consequently, the reserve base has declined. The Reserve to Production ratio (R/P) has generally declined over the last ten years.
- The Indian oil industry has shown limited ability to produce more oil in the last ten years.
- Crude oil imports reached 66% of total crude oil consumption in 1999, or US$8.5bn. This represents 1.3 million barrels per day. The main suppliers are: Saudi Arabia, U.A.E. and Kuwait.

Gas Supply, both onshore and offshore, is concentrated in western India.

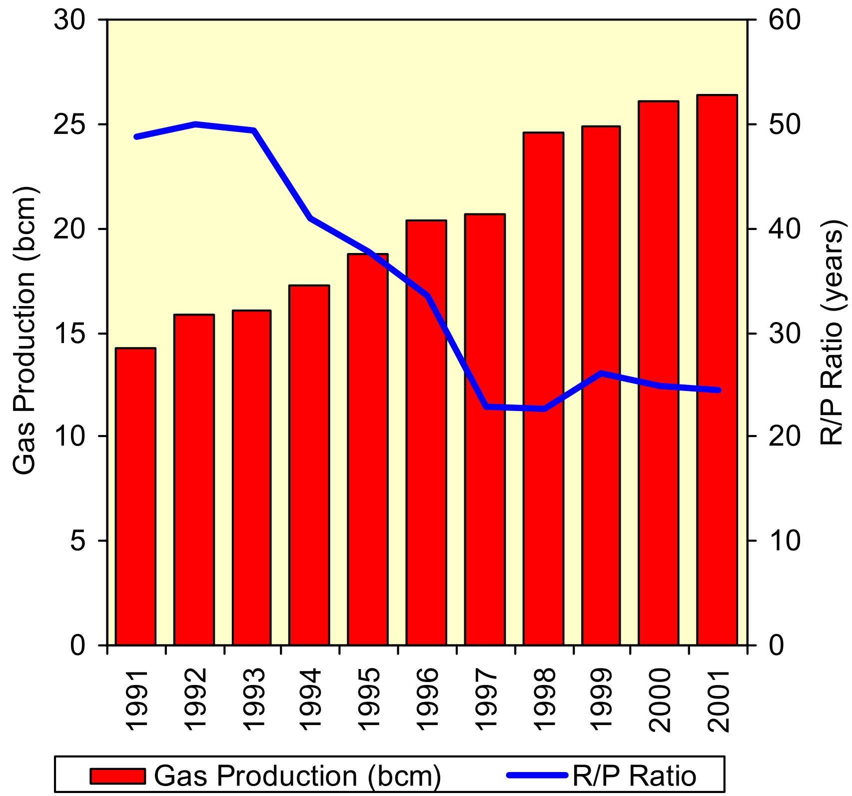
PRINCIPAL GAS PRODUCING REGIONS OF INDIA

Source: Nexant

- Total Indian gas production in 1999/2000 reached 28.5 bcm.
- The western offshore fields provided 74% of India's total gas production in 1999/2000, supplemented by 11% from fields in Gujarat. Production from other regions is relatively low, with the exception of the North Eastern areas.
- There are seven main onshore gas fields, which produced 7 bcm in 1999/2000 or 26% of the total gas production. The biggest fields are located in Gujarat, Assam and Andhra Pradesh and produce 90% of the total onshore gas production.
- Gas has recently been discovered in Krishna Godavari gas field (Andhra Pradesh) with reserves estimated at 7 tcf (196 bcm).
- New gas discoveries have been signalled in Gujarat as well, probably around 1 tcf (28 bcm).

Gas production is at the highest level over the last ten years but new gas finds may trigger important additional production in the western region of Andhra Pradesh

DOMESTIC GAS PRODUCTION VERSUS RESERVES

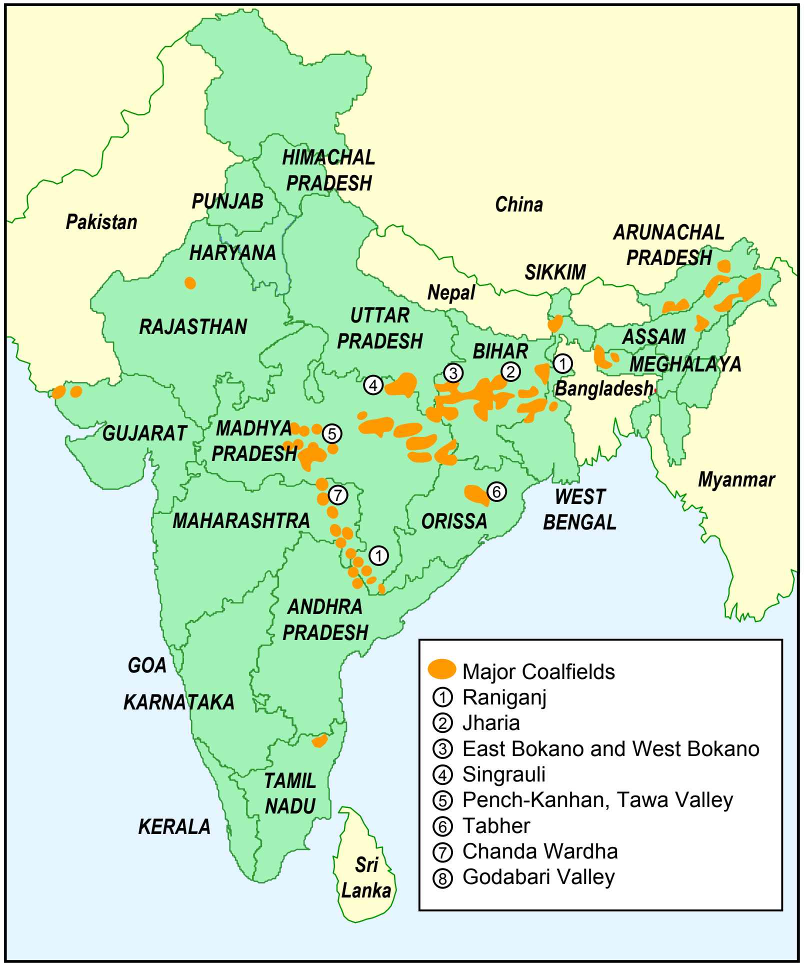


Source: BP Statistical Review of World Energy 2002

- The overall gas reserve life has been in decline since the early 80's and at present is under 29 years of current production.
- Domestic gas production in India has increased over the last ten years. Recent gas finds in Andhra Pradesh are likely to add new production by 2004/05.
- The R/P ratio has generally declined over the last ten years but has been steady since 1999.

The main issue in the gas sector is pricing. The current pricing for domestic gas at US$2/MMBtu makes the import of gas at higher, market prices (e.g. LNG at US$3.5-4/MMBtu) very difficult.

Despite India's large reserves of coal, there has been an increase in coal imports, which reached 18 million tonnes in 1999/2000.

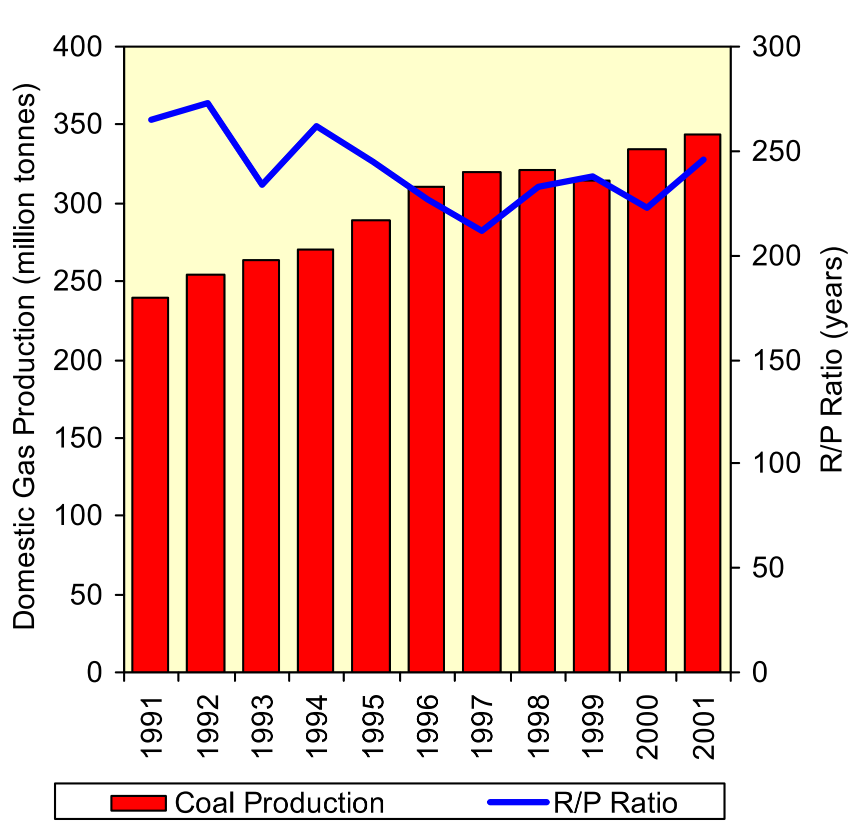


Source: International Energy Outlook 2002, Energy Information Administration

- Coal reserves amount to 82 billion tonnes, representing 7% of the total worldwide recoverable reserves. India is the third largest producer of coal worldwide with 310 million tones in 2001. Coal represents the major conventional energy source. The R/P ratio is estimated at 200 years at the current level of production.
- Most of the coal is subbituminous coal (non-coking). Only 2-3% is coking coal. Indian coal reserves are high in ash content (30-50%), low in heat value and relatively low in sulphur content (<0.5%)t.
- Indian coal is transported by rail to eastern ports and then shipped by water to southern parts of the country. Limited and slow rail transportation is a major problem for domestic coal distribution.
- Coal reserves are located far from the major markets in the central, western and southern parts of India. 37% of the coal is transported to power plants over distances greater than 950km.
- Around 77% of coal produced in India is mined at opencast operations. Productivity standards, even though they have increased over the last ten years, are still below world indices.
- Coal is imported mainly from Australia (more than 50%) and Indonesia (22%)

Coal production has been increasing slightly over the last ten years. The large R/P ratio at current production rates offers comfort that supply is plentiful, provided productivity in mines and coal quality improves.

DOMESTIC COAL PRODUCTION VERSUS RESERVES



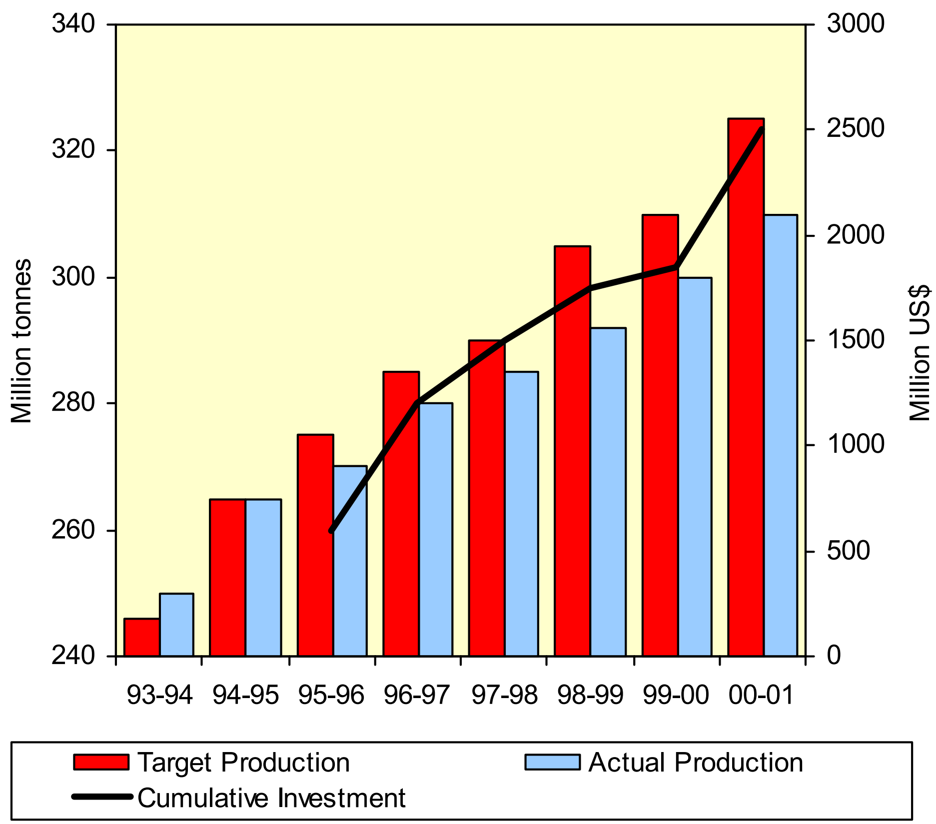
Source: BP Statistical Review of World Energy 2002

- Domestic coal production has been under targeted levels despite the fact that investment in the public coal companies has increased, reaching US$2.6bn over the last six years.
- Due to environmental considerations and transportation difficulties, coal imports have steadily increased over the last decade and in 1999 reached 18 million tonnes, 6% of total coal production. Imported coal is mainly coking coal.
- Imported coal for power generation has become competitive in coastal locations due to high inland transportation costs.

- ***The presence of coal reserves is not an issue in India. The issue is one of quality and poor transportation infrastructure.***
- ***Market reforms – allowing pricing of coal and electricity to reflect the cost of supply; labour reforms; royalty reform and regulatory reform – can make the coal mining industry more attractive to investors.***

Coal production has failed to meet targeted production

TARGETED AND ACTUAL PRODUCTION vs CUMULATIVE INVESTMENT



Source: BP Statistical Review of World Energy 2002

- Since 1995, coal companies performance has been below targeted production. During the last three years, the production deficit was more than 4% of actual production.
- The shortfall has occurred despite significant investment in the public companies which dominate the Indian coal sector. The level of investment reached US$2.6 million over the last 6 years.
- Four of the oldest coal companies (located in Bihar, West Bengal and Andhra Pradesh) are loss making. Three of these are major domestic suppliers.

- ***The key issue is the need for the Government of India to develop a policy to promote reform and private investment in the Indian coal industry.***

Supply of other Forms of Energy

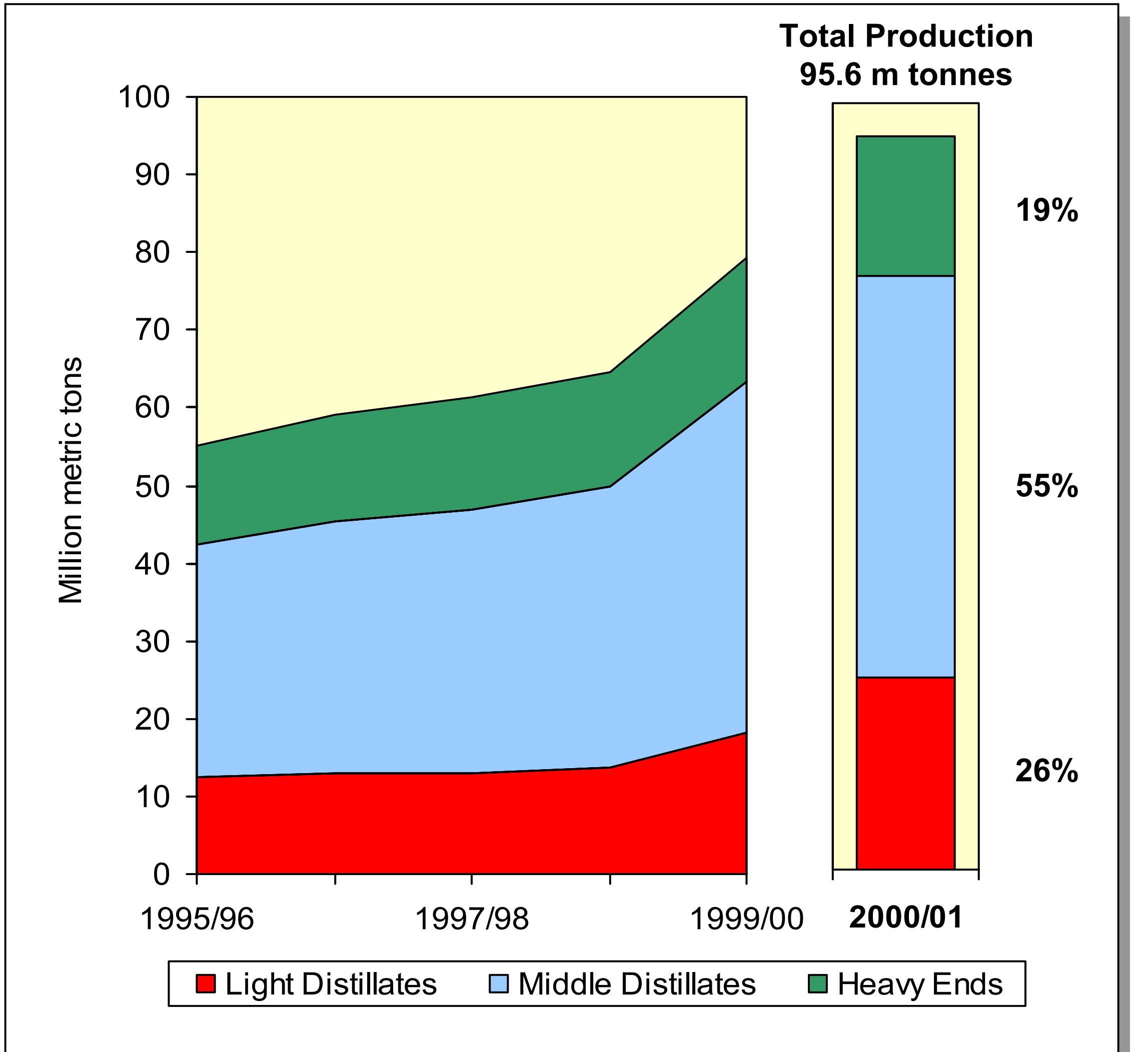
Nuclear Energy

- India has an installed nuclear capacity of 2,430 MW with an additional 3,204 MW under construction and planned to become operational in the period 2005 –2007. The nuclear units under construction are located in Tamil Nadu (2x950 MW), in Karnataka (2x202 MW) and near Mumbai in Maharashtra (2x450 MW).
- India is developing nuclear units in order to diversify the energy mix. Despite the technological, commercial, financial and regulatory issues faced by the Indian nuclear industry, the case for developing nuclear power plants is supported by improved capacity utilisation levels at the existing plants, significant domestic uranium reserves and relative economic attractiveness in locations far removed from coal reserves. The long run marginal cost (LRMC) of nuclear power starts to become competitive if coal reserves are located more than 1,000 km away and no other energy sources (e.g. hydro) are available.
- India's policy for nuclear energy needs to consider the relative risks/rewards of promoting this energy resource in comparison with alternative resources.

Renewable

- Renewable energy sources in India have contributed 1,000 MW to power generation capacity during the eighth five-year plan (1992 – 1997). This represented 7% of total installed capacity.
- The current wind generation units have total installed capacity of 1,267 MW (year 2000).
- Biomass (wood, crop residues animal dung) represents 273 MW.

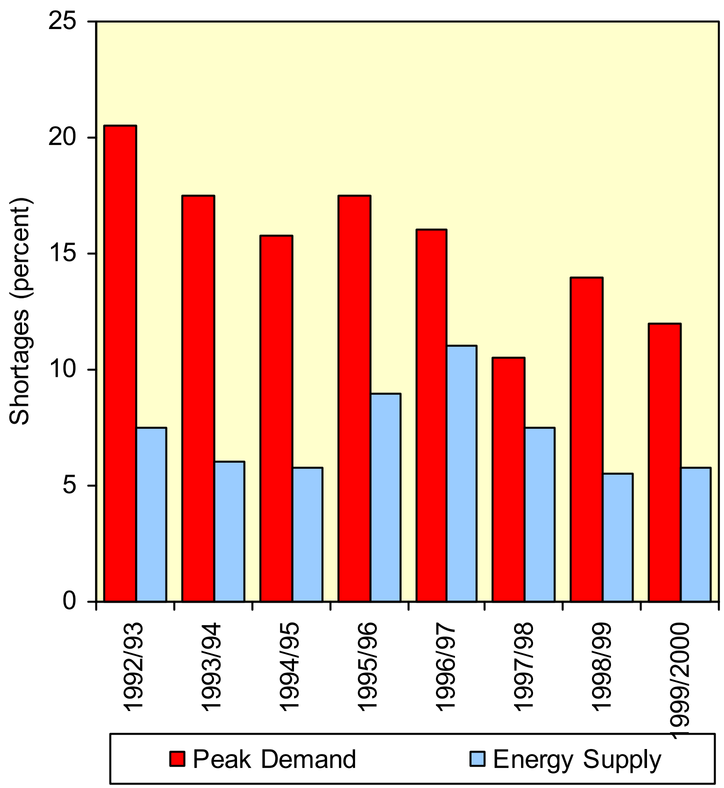
Production of Petroleum Products has registered a boost with new capacity brought online.



- The Indian market has traditionally been long on middle distillates and short on gasoline, as the bulk of the transportation sector runs on diesel fuelled vehicles.
- Consequently, there is a deficit of middle distillates and the indigenous production is supplemented by some 18 million tonnes of imports to meet demand. There has historically been an excess of naphtha, which has been exported – this dropped in the late 90's but with increased refinery capacity is now rising again.
- Kerosene is heavily used as a cooking fuel. Kerosene oil and diesel oil constitute the bulk of imports of middle distillates.

Power generation capacity was planned to grow during the 9th plan by 40 GW but actual capacity addition has materialised at around 50% of the targeted figure.

POWER SUPPLY SHORTAGE



- Installed capacity as of March 2000 was 97,837 MW, 72% of which was thermal power, 24% hydro, 3% nuclear and 1% wind. There are 7 nuclear plants, 45 thermal plants (+5 IPP plants) and 45 hydro plants. Of the thermal plants, 60,000 MW is coal-fired, 9,500 MW gas and 700 MW diesel.
- There is a significant amount of captive generation associated with large industrial consumers. This accounts for 15% of total installed capacity (1999/00) and is concentrated in Gujarat, Orissa, Tamil Nadu, Madhya Pradesh, Andhra Pradesh and Uttar Pradesh.
- The electricity system in India is broken up into 5 interconnected regions with 400 KV networks forming the backbone. The interconnections between the regions have some limitations and there has been investment in recent years to improve the ability to wheel power between regions.
- There are significant discrepancies in terms of electricity supply on a state by state basis and even states with very low demand often cannot meet demand. On occasion, there is also a capacity excess because the transmission infrastructure is inadequate. This highlights the importance of balancing investment in generation with transmission and distribution. Overall, in 1999 there was a 6% electricity deficit, which rose to 12% at peak time.
- India suffers extremely high transmission and distribution losses, with some State Electricity Boards recording losses in excess of 40%! These losses are due to inadequate investment in infrastructure and a lack of proper planning, in combination with defective metering, unmetered supply and theft. The consequence of these high losses is to put pressure on the generation capacity.

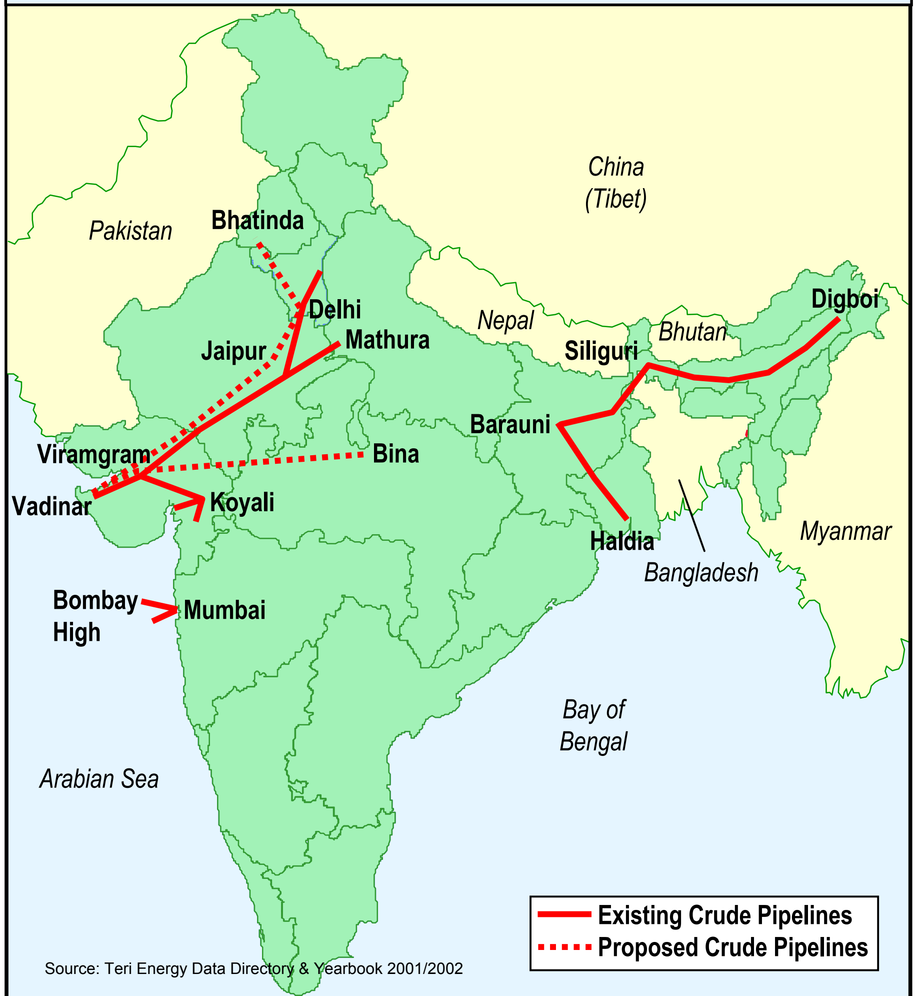
Reform of the Power Sector requires attention to an array of problems that have been affecting the generation, transmission and distribution subsectors. In addition, inadequate end user pricing limits the sector's capacity to provide sufficient supply.

- The power sector in India has has long suffered from mismanagement and political interference. In many states power is sold at below economic costs to politically important groups such as farmers, and State Electricity Board funds have been used to support politically motivated state spending.
- In addition, there is substantial cross subsidy in retail tariffs from the industrial and commercial sectors to domestic and agricultural consumers.
- India suffers extremely high transmission and distribution losses. The reform process has increased transparency and revealed that most states have higher than previously reported losses. In Andhara Pradeh, Haryana and Uttar Pradesh T&D losses are estimated at 51%, 40% and 42% against reported figures 25%, 32% and 27% before restructuring.
- The combination of uneconomic tariffs, financial impropriety, losses and theft mean that few State Electricity Boards are solvent. In the last year for which data is available (1999/2000) only two SEBs made a positive rate of return on net fixed assets. Consequently SEBs have no funds for investing in improvements to transmission and distribution infrastructure.
- There is a process of reform which is taking place within the power sector where the states are creating State Electricity Reform Commissions (SERCs) to oversee the unbundling of generation, transmission and distribution and the implementation of tariff reform. So far, the states of Orissa, Haryana and Andhra Pradesh are most advanced on this route.

V Energy Infrastructure

Crude oil infrastructure needs to be expanded to handle imports – the growth of national tonnage should be increased to save foreign exchange outflows on account of freight bill

CRUDE OIL INFRASTRUCTURE IN INDIA

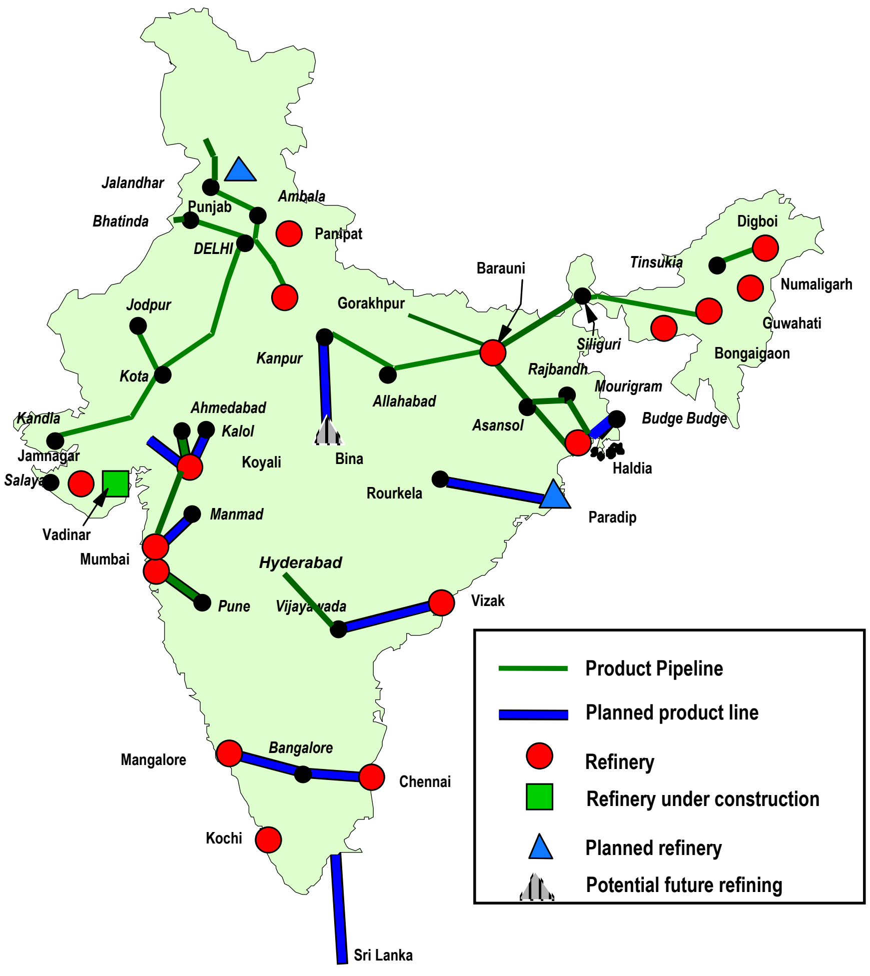


Source: Teri Energy Data Directory & Yearbook 2001/2002

Crude Oil Infrastructure

- Petroleum products are primarily moved by rail tank-wagons and pipelines. In 1999, 38% of products were moved by rail with 26% moved by pipeline. The quantity moved by rail has stayed constant for several years and is expected to decline due to the cost of procuring wagons and congestion on the system.
- Oil is handled at 13 ports in the country, which in 1999 handled 107 million tonnes of oil and oil product imports and exports. Existing port infrastructure suffers from severe capacity constraints in terms of draft, jetty availability and navigation facilities.

Crude oil refining capacities are mostly located close to the western developed markets but the transmission infrastructure constrains product movements

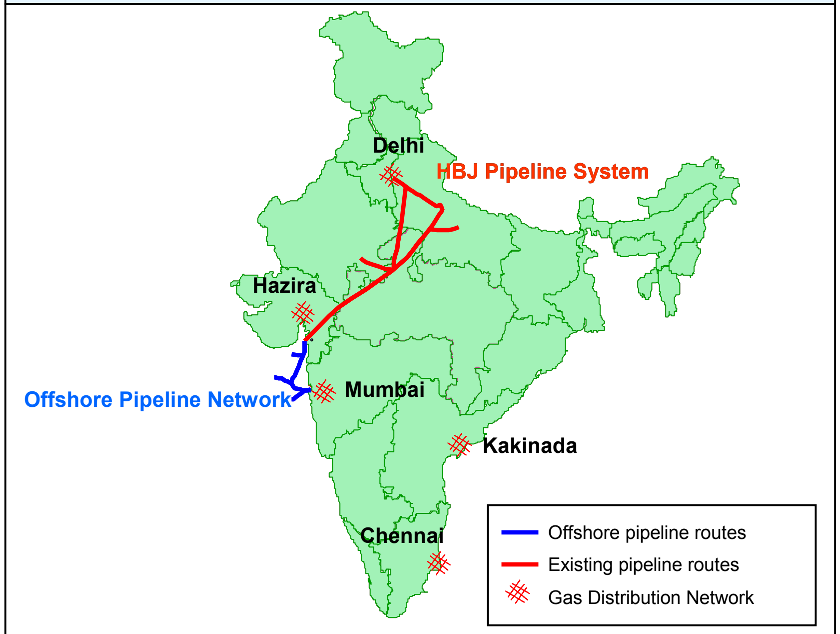


Source: HIS Energy Group, India Energy Map, Sept 2001

- India has 17 refineries with a nominal crude distillation capacity of around 106 million tonnes per annum. Many of these refineries are old and well below world scale.
- The only world class refinery in India is the Reliance refinery in Jamnagar, Gujarat which increased India's capacity by 25% on completion in 2000 (27 MMPTA)
- There is a concentration of refining capacity in the west of the country – 60% of refining capacity is located on the western coastline. The refineries on the east coast tend to be old and small.
- The oil downstream sector, though offering enough capacity, is not efficient in movement of products to the markets. The western coast is well served but the few modern refineries placed in this region produce more than is needed in the local market.
- An additional unit at Jamnagar refinery is underway and will bring another 10 million tonnes capacity by end 2002.
- Refinery construction has been encouraged by the Indian government by offering a tax holiday for refineries built before 2003.
- By 2002 there were almost 5,000 km of product pipelines in India. The pipeline system is under expansion and there are a number of pipelines under development.

Gas Infrastructure

MAJOR GAS INFRASTRUCTURE



Currently gas infrastructure exists for production and transportation of about 90 MMcm/day of gas and transmission and distribution of about 65-70 MMcm/day.

Most of the infrastructure is installed in the west and north west for transportation of gas to shore from the western offshore fields and transmission of this gas to end users.

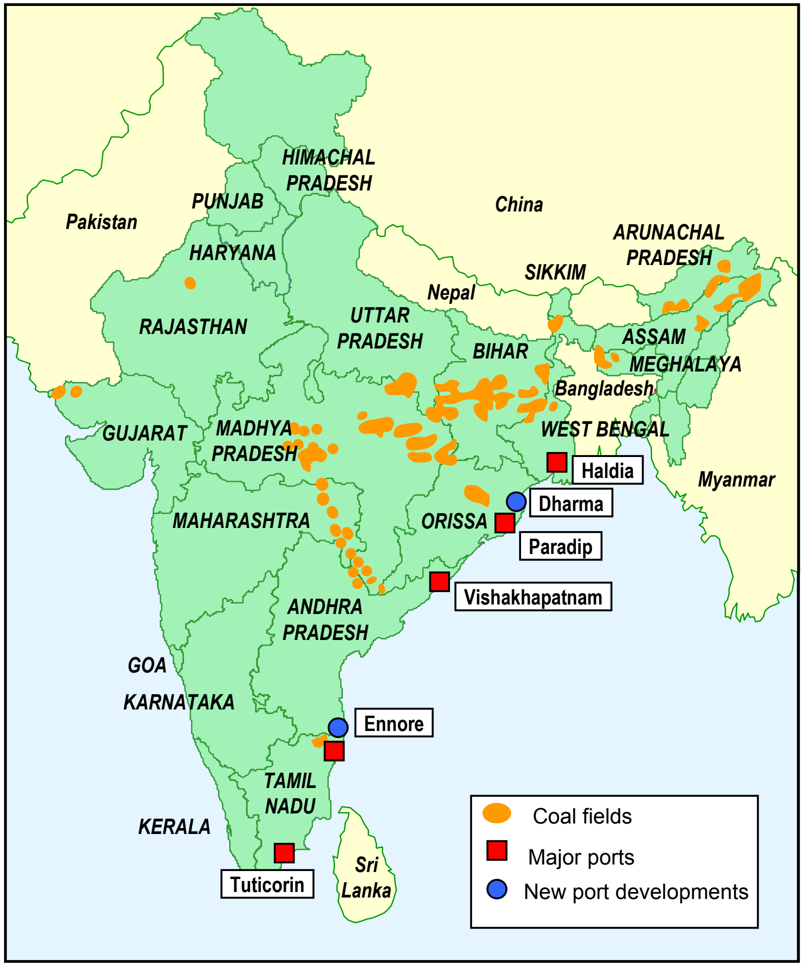
Onshore Infrastructure

- The major gas infrastructure network in India is the HBJ transmission line which is 2,300 km in length and connects the offshore gas fields to Delhi through the industrial belt of Gujarat.
- The capacity of the HBJ system reached 0.033 bcm per day in 1998.
- To facilitate LNG imports, HBJ expansion is under construction and planned to be completed by October 2003. The expansion will increase the pipeline capacity by 0.06 bcm per day.
- There are regional gas grids, of varying sizes, in the states of Gujarat (Cambay Basin), Andhra Pradesh (KG Basin), Assam (Assam-Arakan Basin), Maharashtra (Ex-Uran Terminal), Rajasthan (Jaisalmer Basin), Tamil Nadu (Cauvery Basin).

Offshore Supply Infrastructure

- There are around 3,700 km of offshore gas pipeline, of which almost 1,000 km is gas trunk line networks. The Western offshore region contains most of India's production infrastructure and the fields supply the Uran and Hazira terminals.

Despite India's large reserves of coal there has been an increase in coal imports, which reached 18 million tonnes in 1999/2000.



Source: International Energy Outlook 2002, Energy Information Administration

- Location of primary steam coal consumers is in the NW and in coastal areas, far from the largest producing mines in the eastern and central states and far from the ports
- More than 30% of the coal requires shipment of over 500 km
- Almost 80% of imported coal arrives in Orissa and West Bengal. The rest is imported in the south at Chennai in Tamil Nadu.
- Lack of facilities to accommodate capesize and panamax vessels is a major impediment for economic seaborne coal trade. A new facility under construction for panamax vessels is Dharma (16 million tonnes per year).
- There are 8 importing coal ports with a total capacity of 42 Mt/a. The main ones are: Ennore, Paradip, Tuticorin and Vishakhapatnam.
- There are 4 exporting coal ports with a total capacity of 23 Mt/a. A significant capacity expansion (27 Mt/a) is planned at Paradip to meet the need from new power plants in the region.

Coal infrastructure expansion is essential to the industry's sustainability.

- Around 77% of the coal produced in India is mined at opencast operations, which have increased steadily in the last 15 years. This triggered productivity improvements, but many mines still rely on manual labour for many activities due to the lack of large-scale earth moving equipment.
- Average opencast productivity at some mines (CIL and SCCL) ranges between 1,200 tonnes to 1,675 tones per miner-year, well below world commercial coal mining standards * . Other mines (e.g. in Orrisa, Uttar Pradesh and Maharashtra) have an average productivity of 2,500 tonnes.
- Underground mining productivity is among the lowest of major coal producers. This sector lacks mechanical equipment and advanced mining techniques and suffers from poor planning. As an example, in 1999, more than 60% of the country's underground coal was produced in unmechanised mines.
- There is an acute shortage of coal washing capacity, mainly for thermal coal.
- The main ports importing ports are: Tuticorin (3 MT/a) , Vishakapatnam (3.3 MT/a) and Paradip (8.5 million tonnes/year).
- The main exporting port is Paradip with a throughput of 3.5 MT/a.

** Comparison of productivity levels between countries is indicative due to the fact that there are many differences in reporting production and employee data. According to IEA Coal Information 2001 the following productivity levels have been reported:*

Australia: 12,000 - 15,000 tonnes per miner-year

South Africa: 3,900 tonnes per miner-year

China: 2,890 tonnes per miner-year

Summary gas, crude oil and petroleum product pipelines

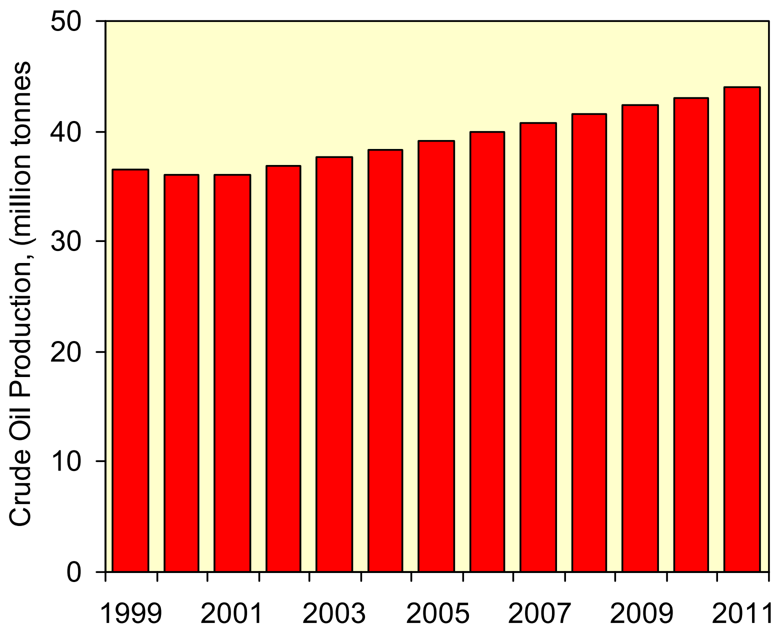
Pipelines	Length (km)	Capacity	Comments
Crude Oil			
Existing	**4,800**	**33 million tonnes / yr**	**2 pipelines**
Under Construction	**Approx 400**	**3.2 million tonnes / yr**	**1 pipeline expansion Haldia-Barauni**
Planned	**Approx 2,200**	**12 million tonnes / ys**	**2 pipelines: Vadinar / Bina and Mundra / Bhatinda**
Petroleum Products			
Existing	**4,827**	**28.85 million tonnes / yr**	**11 pipelines**
Under Construction	**Approx 500**	**NA**	**2 pipelines – south and west of India**
Planned	**Approx 1,000**	**NA**	**5 pipelines**
Gas			
Existing	**4,400**	**0.133 bcm / day**	**Out of which HBJ 2,300 km and transport 0.1 bcm / day**
Under Construction	**1,900**	**0.06 bcm / day**	**Expansion HBJ; GSPC (1200 kms gas grid); DAHEJ - Vijaipur (610 kms)**
Planned	**NA**	**NA**	**2 pipelines in Krishna / Godavari and Cauvery basins**

Source: TERI Energy Data & Directory Year Book 2001/2001; India Infrastructure Vol 4, July 2002; HIS Energy Group, India Energy Map, Sept 2001

VI Energy Supply Forecast

Domestic crude oil supply is projected to grow at a modest rate.

PROJECTED CRUDE OIL SUPPLY FORECAST FROM INDIA'S DOMESTIC RESERVES



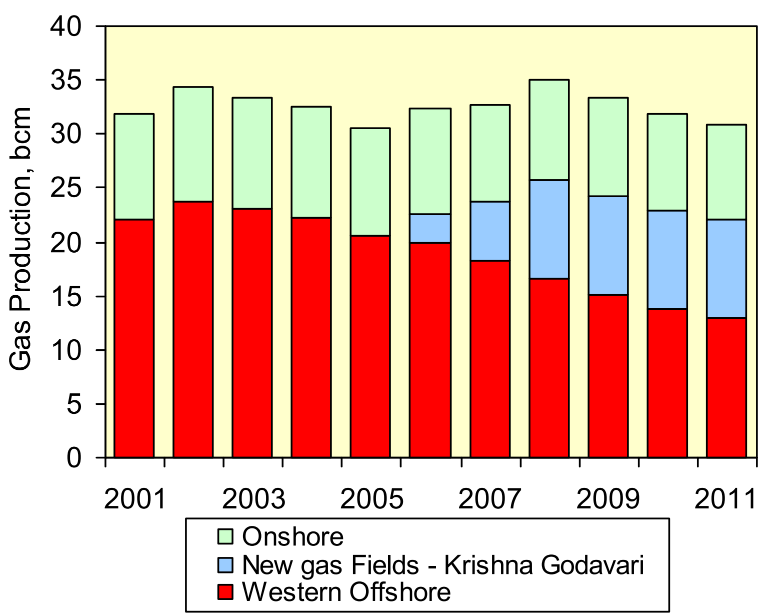
To increase the reserve base a combination of intensive exploration in the producing areas and an extensive exploration in prospective areas (deep waters) would be required.

Crude Oil Supply Forecast

- India has 26 sedimentary basins, and is relatively unexplored in terms of the exploration and drilling activity that has taken place so far. However it is not considered to be highly prospective for oil by the international oil industry. This is mainly due to low drilling recovery rates of around 30%, well below the world average, and a view that India's easily recoverable reserves have already been discovered.
- To increase the reserve base, a combination of intensive exploration in the producing areas and an extensive exploration in prospective areas (deep waters) would be required.
- A New Exploration and Licensing policy was established in 1999 to boost oil and gas production and to encourage exploration in deepwater blocks. However, the two bidding rounds that have been held have failed to attract any of the world's major exploration and production companies.
- Based on the current level of investment in exploration, crude oil production is set to grow at modest rates.

Major gas finds are needed to reverse the declining gas production trend

PROJECTED GAS SUPPLY FROM INDIA'S DOMESTIC RESERVES (bcm)



Source: MoPNG, India Natural Gas Development Plan, ADB

A new exploration policy is under implementation and is expected to stimulate greater interest in the Indian Exploration and Production (E&P) sector from the international oil industry.

Natural Gas Supply Projections

- Gas production from established Indian oil and gas fields is expected to reach a peak of around 36bcm in 2002 and then slowly decline to around 25% of this level by 2020. However, over the next ten years, the estimated gas supply is projected to drop to 25 bcm.
- The largest producing fields, the Bombay High (associated) and Bassein field (free gas), which currently provide almost 60% of total gas production, are both in decline, as is production from the North and South Gujarat fields.
- The new gas find at Krishna Godavari gas field will boost the domestic supply, and production from this field will start to make an impact by 2006, although this will depend upon infrastructure development.
- There is considerable potential to develop supply from the North Eastern region, principally Assam and Tripura, and there is a ready demand for this gas.
- It is believed that some of the deeper offshore prospects, particularly off the South Western and East coasts may have potential to provide large reserves.

Natural gas supplied as Liquefied Natural Gas (LNG) is a substantial potential source, in the context of the slow progress being made by pipeline gas imports, provided an adequate pricing structure is found.

Natural Gas Supply as Liquefied Natural Gas (LNG)

- Recognising that the supply of domestic natural gas would not be sufficient, the Ministry of Petroleum and Natural Gas has sought LNG supplies. By the late 1990's there was a proliferation of LNG projects although thus far only two have progressed to the construction stage (Dabhol, Maharashtra and Dahej, Gujarat).
  - The most advanced LNG terminal is the Dabhol project in Maharastra which by the time construction was halted in June 2001 was 90% complete. This project is now halted subject to the untangling of the affairs of the Enron Group. It is likely that another developer will take this project over once these issues are resolved.
  - The government backed Petronet LNG terminal at Dahej in Gujarat is now around 40% complete. This terminal will tie into the HBJ pipeline system via a new pipeline extension. This terminal is designed to take 5 MTPA of LNG – about 6.8 bcm.
- Five more LNG terminals are planned or proposed for a total of 18.7 MT/a on both west and east coasts.
- The development of LNG projects are at present hampered by the gas pricing issue which is yet to be addressed by the Indian Government. Domestically produced gas is delivered at approximately half the price at which LNG will be available.

Other gas supply sources are unlikely to contribute to the energy balance until they become viable and economic.

Other Gas Sources

Coal Bed Methane

- Coal-bed methane is believed to be a significant future source of energy. Current estimates are 1,500 bcm, which represents some 2.5 times the proven natural gas reserves in the country. Sources of coal bed methane are naturally located in the coal bearing regions. Some blocks have been identified in Bihar, Madhya Pradesh, Gujarat and West Bengal and a few pilot projects are being implemented.
- However there are a number of issues related to coal bed methane – although the gas is at relatively shallow depths, it is difficult to produce and requires a large drilling effort. Wells are often of very low productivity, and once shut down a well will not not recover its original flow rates. CBM is produced at low pressure and requires expensive compression to allow transportation to remote users.
- A secondary problem for coal bed methane lies in its concurrent location with coal, a fuel with which it competes.

Gas Hydrates

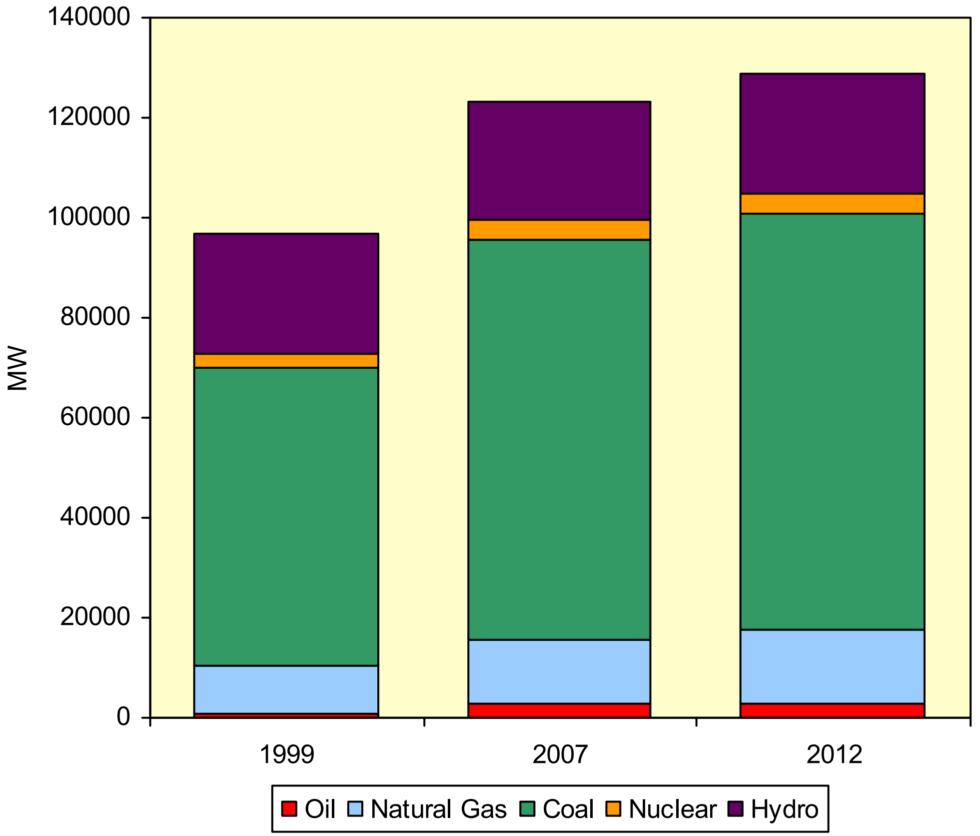
- India is believed to have very significant gas hydrate deposits in the offshore regions, although it is recognised that development of gas from gas hydrates is in its infancy world-wide, and major technological challenges have to be overcome before commercial exploitation is a realistic possibility.

Increasingly the future supply of coal will be heavily dependent upon reform in the coal sector. Key issues are mine productivity, environmental concern and the relationship with the electricity sector.

- **Coal Supply Projections**
- Targets for coal production were set by the Planning Commission at 370 MT for 2001/2 499 MT for 2006/7 and 672 MT in 2011/12. These targets look extremely ambitious given that production rose from 213 MT to 300 MT over the last decade. To meet these targets coal production will need to increase at a rate of 6% per year.
- In order to improve coal production productivity, mines will have to use more modern mining methods, better technology and management.
- Washing of Indian coal is difficult because of its high ash content and investment is needed in washing facilities. So far there has been a failure to improve washeries to the requisite standard. This has had two consequences:
  - large quantities of ash are being transported with the coal putting a large burden on the rail network.
  - some industries are turning to imports. The steel industry has been heavily dependent upon imports, and this trend will continue into the power sector. (Already power consumers in Delhi and Bombay utilise imported coal).
- The associated infrastructure (rail, roads and domestic ports) will need substantial capacity expansion in order to meet increased production. The railway system in particular is a major problem – and the cost of coal transportation by rail in India is amongst the highest in the world, as it is used to cross-subsidise agricultural and passenger fares.
- Imported coal is competitive in coastal locations, at large distances away from domestic pithead mines.
- At present, existing government policy only allows private ownership of mines if they are captive operations which feed a power plant or factory. The government has backed away from further plans for coal sector liberalisation in the face of strong opposition from unions.

New generating capacity will have to be added at rates higher than those achieved during the 9th plan

PROJECTED POWER GENERATION CAPACITY BY TYPE OF FUEL



Source: TERI 2001; MOP 10th Plan

Electricity Supply Forecast

- Average annual growth by 2020 in net electricity consumption is projected at 4.9 %, second only to China's (5.7 %).
- According to the 10th plan, up to an average of 10,000 MW of additional power per year is required over the period to meet demand.
- The majority of capacity increase is in coal and gas-fired thermal power plants.

Hydropower capacity, though encouraged by the government, has long development stages and is unlikely to attract foreign investment

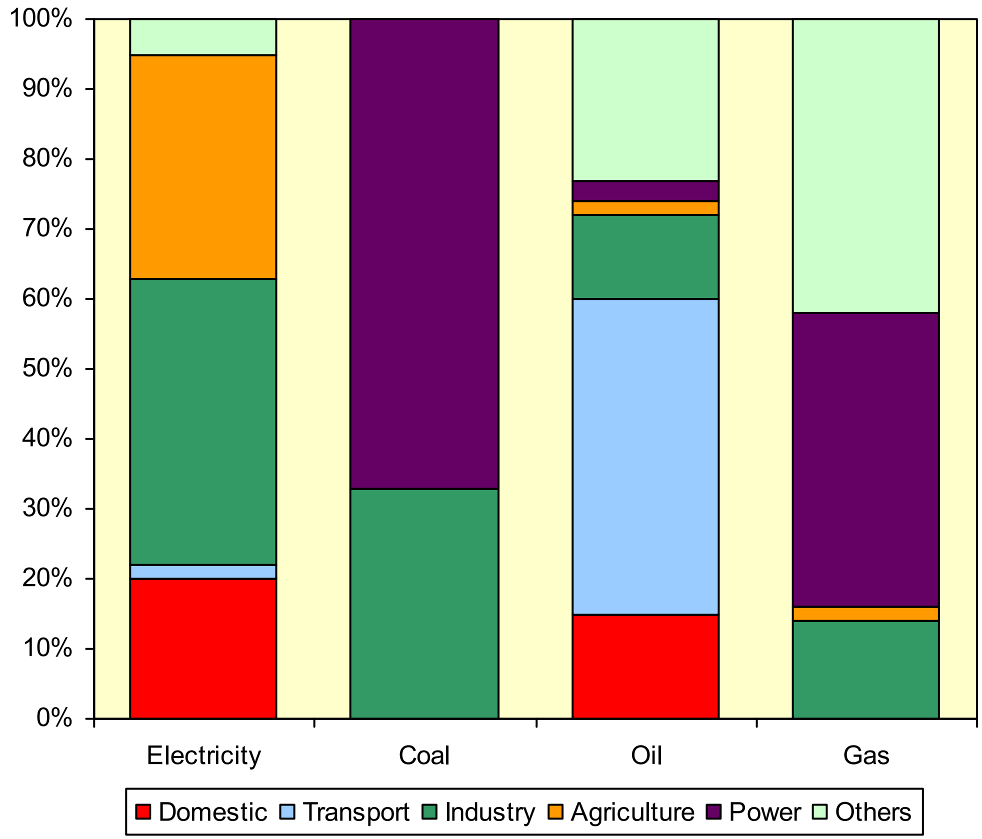
Hydropower Supply Projections

- Currently India has around 24,000 MW of installed hydropower capacity with an additional 9,000 MW under development. The ideal hydro–thermal mix is stated as 40-60 for India, although at present hydropower accounts for only 24% of supply.
- India has an assessed hydro potential of 84,000 MW, but development of hydropower has slowed in recent years due to interstate water-sharing issues, difficulties in project development, lack of demand in home states and social environmental issues such as displacement of villages.
- The government has plans to increase hydro capacity by 4,100 MW by 2004/5, primarily using taxes and subsidised electricity tariffs.
- Although there is significant potential, developing hydropower projects will be difficult. Recent projects have run into major difficulties from environmental activists, and project gestation periods have been extremely long, resulting in diminished rates of return for developers.
- The funding of hydro projects is currently out of favour with multilateral financial institutions due to environmental consequences, so it will be extremely difficult to fund major projects.

VII Energy Demand

Total energy consumption reached 314 mtoe in 2001

ENERGY CONSUMPTION PATTERN
1998/99



Source: TERI (2000)

Energy Consumption

- The dominant sectors in primary energy consumption are power generation (28%of total consumption) , industry (22 %) and transportation (15%).
- Oil consumption is concentrated in the **transportation sector** where 0.9 million barrels of oil were consumed daily in 1999. This quantity is projected to grow to **2 million barrels by 2010**.

Electricity demand is forecasted to grow by 5-6% per year but reform of the sector is required to assure sustainability

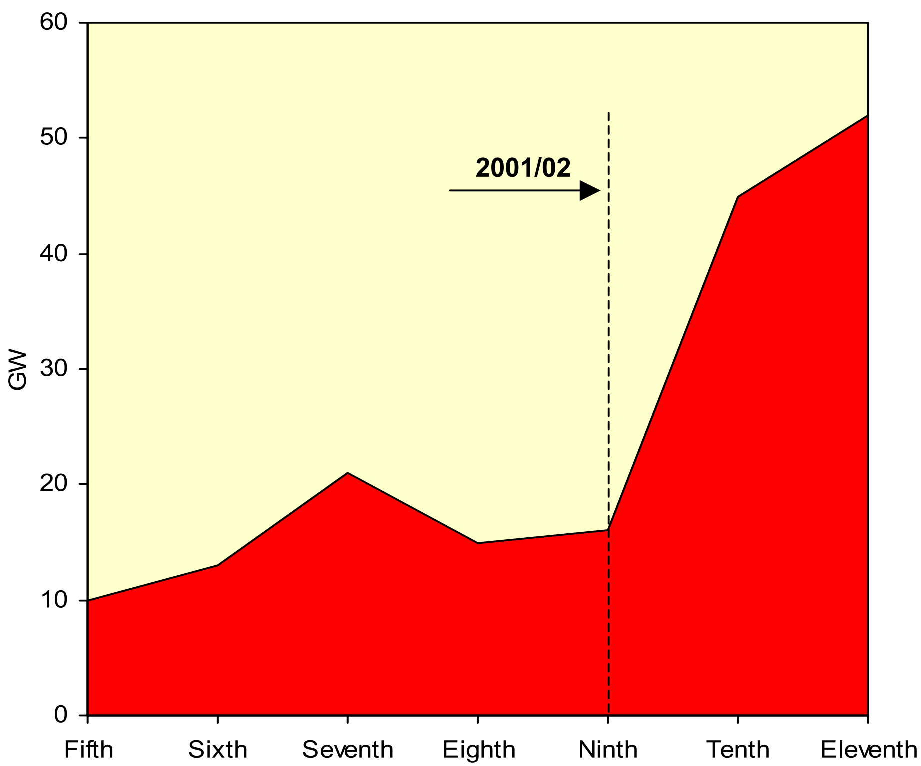
Electricity Demand

- Demand for electrical power in India is potentially huge, as is reflected in the demand figures of the 5 year plans prepared by the Ministry of Power. Electricity peak demand is forecasted to rise to 131,000 MW by 2007 (end of 10th plan) and 176,000 by 2012 (end of 11th plan).
- It should be noted that these demand figures are based on prevailing electricity pricing structures, where vast amounts of power are subsidised or taken without payment. Reform of the power sector, bringing prices to economic levels, coupled with better management of delivery and cash collection should result in more efficient use of power in India and should also reduce incremental demand. However, even with better demand side management, incremental demand will still be substantial in order to supply a population where the per capita consumption of electricity is only 6% of that in a western economy.
- The demand elasticity of electricity for India is 0.97 (i.e. for every 1 % in GDP growth electricity consumption increases by 0.97%) and this is under a constrained environment. Even under conservative demand scenarios, power demand in India is likely to increase by 5-6% per annum.
- At present, India is subject to regular power blackouts due to insufficient generation and transmission capacity and an inability to wheel power efficiently through the country. Significant investment is required in order to redeem this situation.

The domestic electricity sector would have to grow significantly over the next ten years to meet forecasted demand.

ELECTRICITY CAPACITY ADDITIONS

(to reach the planned new capacity additions, the rhythm of installing this capacity would have to increase significantly)



Source: Teri, Defining an Integrated Energy Strategy for India, 2002

- Capacity additions during the 10th Plan period between 2002 and 2007 are estimated at a total of 41,097 MW
- The 11th Plan projections are not available at present. However, it is estimated that India needs a capacity addition of 60,700 MW between 2007 and 2012.
- 43% of capacity additions during the 10th plan are under construction, 22% are represented by approved projects and 35% are still to be approved. Considering the track record of adding new capacity at the rate of around 5,000 MW per year, it is unlikely that planned capacity (see above) will be brought on line in time to meet forecast demand.
- More than 70% of electricity capacity in India is based on coal and nearly 75% of coal production would be needed for power generation. To achieve this, demand for imported coal would have to grow.

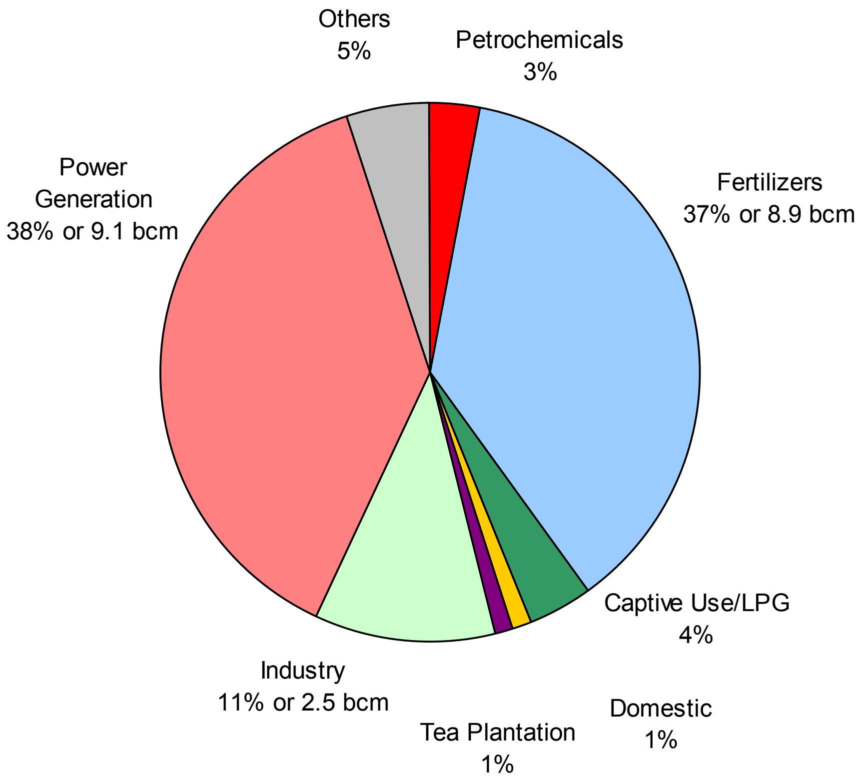
Crude oil demand will be met largely by imports whereas products demand is now met by domestic supply

Crude Oil and Oil Products Demand

- Currently, oil accounts for about 30% of India's total primary energy consumption (2001). The current total consumption of crude oil is 97 million tonnes of which 60% is imported. Total consumption is projected to grow to 170 Million tonnes by 2010 and up to 250 million tonnes by 2020. This is an average growth rate of 6.5% per year.
- Ministry of Petroleum and Natural Gas (MoPNG) estimates that by 2010 India will have an import dependence of 80% for crude oil if production remains at the current level and consumption grows as indicated above.
- Future product demand will be driven by the transportation sector.
- The mix of product demand may change with the dismantling of the administered pricing mechanism (APM), which will bring import parity pricing to all products. This could increase demand for gasoline.

Natural gas demand is driven by the power sector, which is the premium use of gas

GAS CONSUMPTION STRUCTURE BY END USER, 2000 TOTAL CONSUMPTION 23.8 bcm



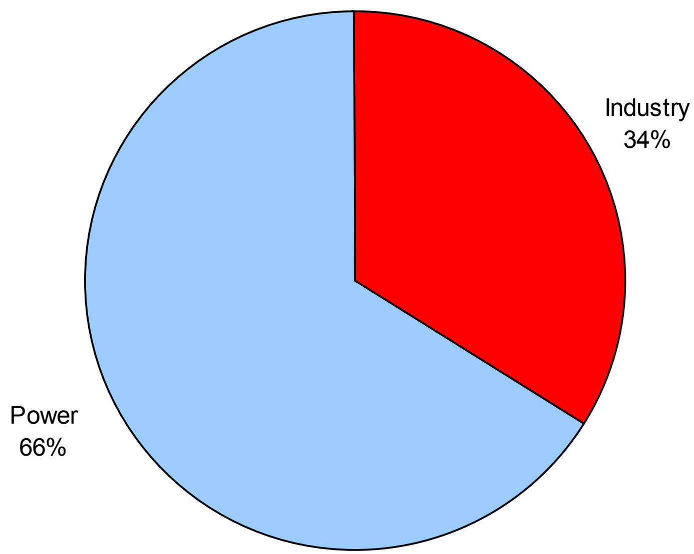
Source: TERI Energy data Directory 2000/2001

Natural Gas Demand

- The existing demand for gas in India has been heavily constrained by supply, and gas usage is primarily for power and fertilisers in the Bombay area and along the HBJ pipeline route. Around 41% of gas produced feeds fertilizer plants, while power generation accounts for another 37%.
- Gas demand is currently around 24 bcm and is forecast to rise to around 75 bcm by 2010 and 95 bcm by 2020.
- Over 75% of incremental gas supply will go to the power sector, which is the premium user of gas. It is not likely that any incremental gas will go into fertilizer production given that incremental gas is likely to be significantly more expensive than current gas prices.
- The incremental demand, particularly in the 2002-2007 period, will be primarily in the west and north-west of India, in Maharastra, Gujarat and along the HBJ pipeline corridor to the Delhi region.

Coal demand is sensitive to transportation charges. The growth of coal imports consumed by power plants suggest that coastal locations can be supplied cheaper from imports.

COAL CONSUMPTION STRUCTURE BY END USER, 2000
TOTAL CONSUMPTION 343 MILLION TONNES



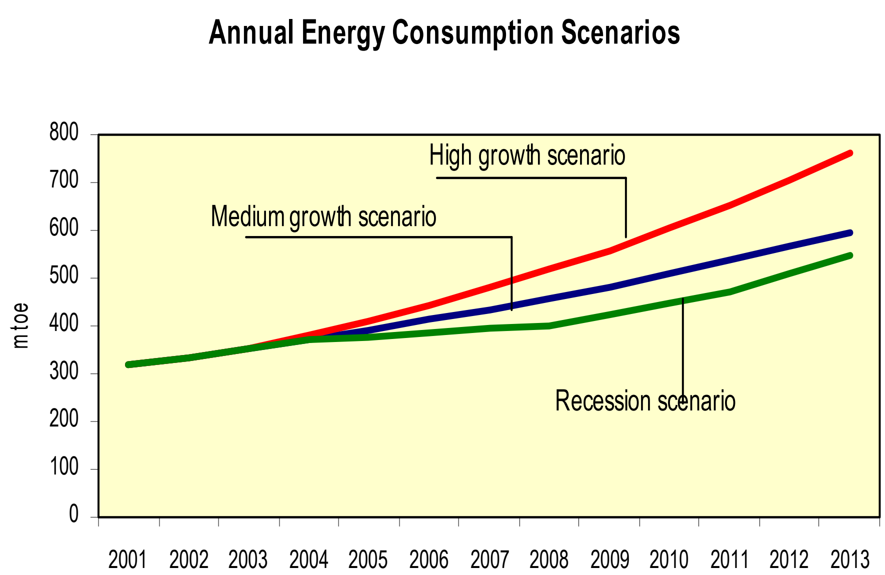
Source: TERI Energy data Directory 2000/2001

Coal Demand

- The Planning Commission assessed the demand for coal at 545 MT in 2006/7 and 775 Mt in 2011/12 from the current production level of 300 MT.
- The IEA World Energy Outlook is more conservative and has projected demand to reach 480 MT by 2020. This demand consists of 434 MT of thermal coal and 46 MT of metallurgical coal.
- In order to meet this lower demand, India will need to expand hard coal production by 2.2% annually.
- In parallel with this expansion, development of rail infrastructure, roads and domestic port facilities will be needed in order to ensure that coal production can be transported to market.
- It is difficult to envisage the domestic coal sector meeting the Planning Commission demand targets, which would require a doubling of production by 2011.

A high economic growth rate would more than double the present energy consumption level by 2013 if it were to be achieved

ENERGY DEMAND SCENARIOS



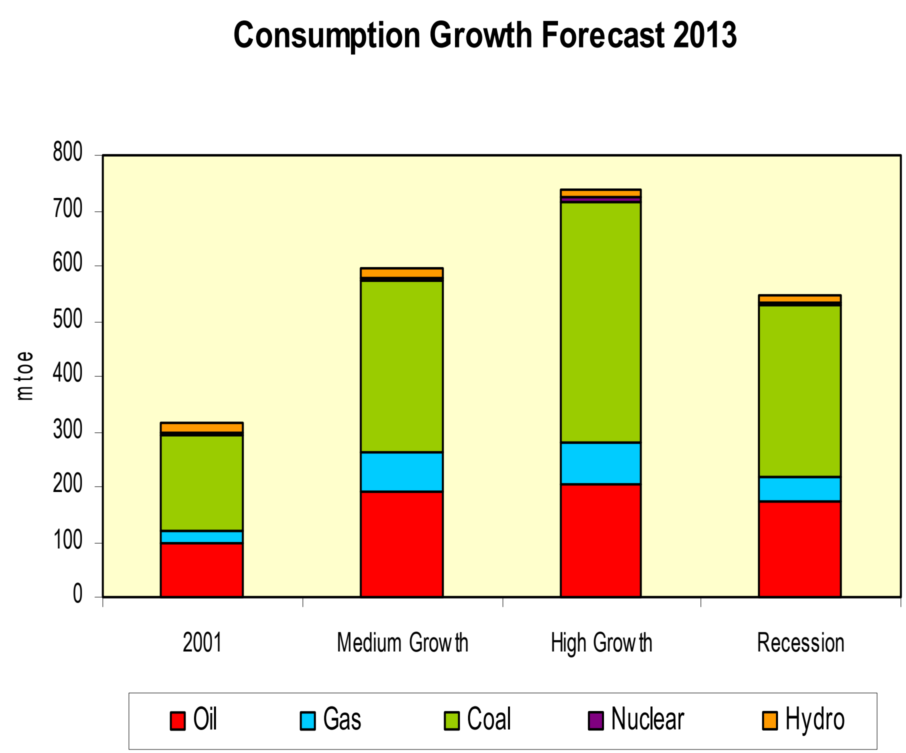
Source: Nexant Forecasts

Overall Energy Demand Forecast

- The energy forecast publicly available are very ambitious and are compatible with a high demand growth scenario wherein GDP growth rate reaches 8% and stays at this level over until 2013.
- The total energy demand forecasts are based on an energy intensity of 693 toe per US$ 1million of GDP.
- The high growth scenario assumes a GDP growth rate of 8% over the next decade. The total energy consumption would reach 740 mtoe.
- The medium growth scenario assumes a GDP growth rate of 5.4% over the next decade, continuing the recent trend of the Indian economy. In this case, the total energy demand would grow to almost 600 mtoe.
- An economic recession (GDP growth rate 2%) lasting 2 to 3 years, starting with 2005 and followed by recovery to the GDP growth encountered beforehand (GDP growth 5.4%), would limit the energy demand. The overall annul consumption would reach 540 mtoe.

Coal is forecasted to remain the dominant energy fuel, natural gas the fastest growing whereas the crude oil will increase but maintain a stable share of the primary energy consumption mix.

ENERGY DEMAND SCENARIOS



Source: Nexant Forecasts

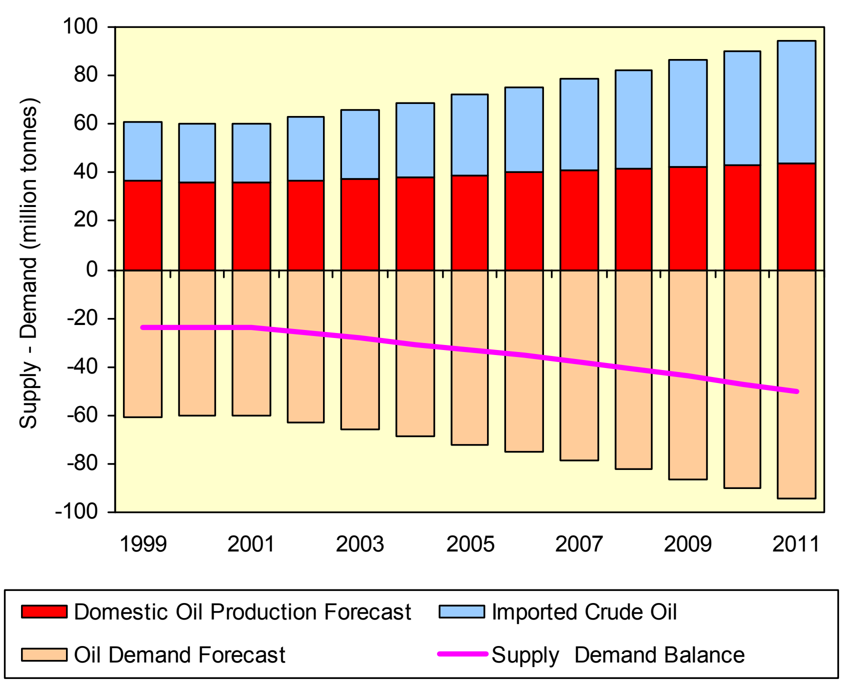
Energy Mix Forecast

- The energy mix forecast in India (forecasting scenarios on previous page) shows that most of the increment in energy consumption in all scenarios is in the form of gas and coal. A high growth scenario would trigger the doubling of the present gas consumption by 2013. The coal consumption would also increase as the country will try to maximise the utilization of domestic supply.
- The crude oil consumption is not affected during a recession scenario as the consumption is primarily driven by transportation which is likely to increase regardless of an economic slowdown. Oil would maintain a relatively stable share of the primary energy consumption under all scenarios.
- Coal is forecasted to remain the dominant energy fuel throughout to 2013 and maintain a 55% to 59% share of total energy consumption.
- Natural gas is projected to be the fastest growing primary energy sources, raising from 24 bcm in 2001 to 73bcm in 2013 in high growth scenario.

VIII Energy Supply / Demand Balance

The high correlation between crude oil consumption and GDP growth implies that estimated economic growth will trigger a continued high level of crude imports.

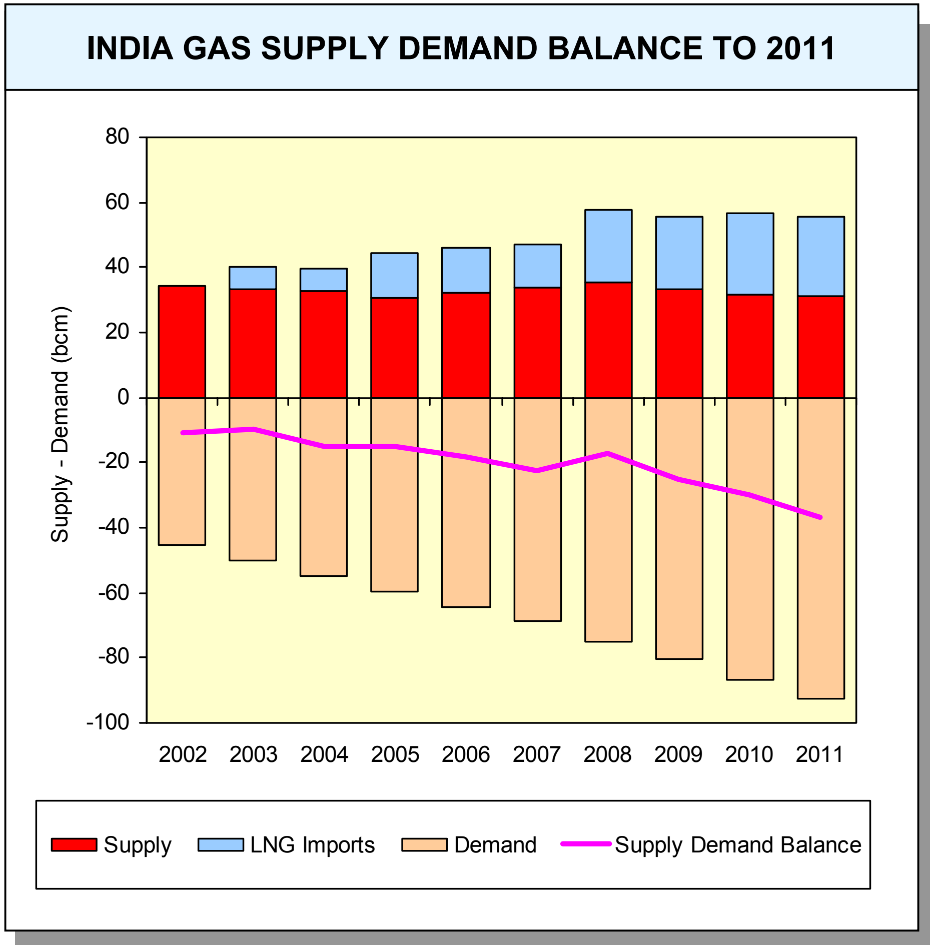
INDIA CRUDE OIL SUPPLY DEMAND BALANCE TO 2011



Crude OIl	2000	2010	2020
Domestic Supply	30	36	45
Demand	67	170	250
Shortfall	37	134	205
% Imports	55%	79%	82%

- The demand for crude will far exceed domestic supply, and the gap between supply and demand will grow substantially over the next two decades.
- The crude import requirement will rise from almost 70% of consumption now to about 80% in 2010, assuming modest growth in domestic crude oil output. This assumes that new fields are discovered under exploration activities currently taking place.
- This level of crude demand assumes that India continues to expand refinery expansion to keep pace with product demand.
- The crude oil balance indicates that India faces a very substantial foreign exchange exposure over the next decade as the crude oil deficit increases.
- There will also be substantial pressure on infrastructure to supply products to the market.

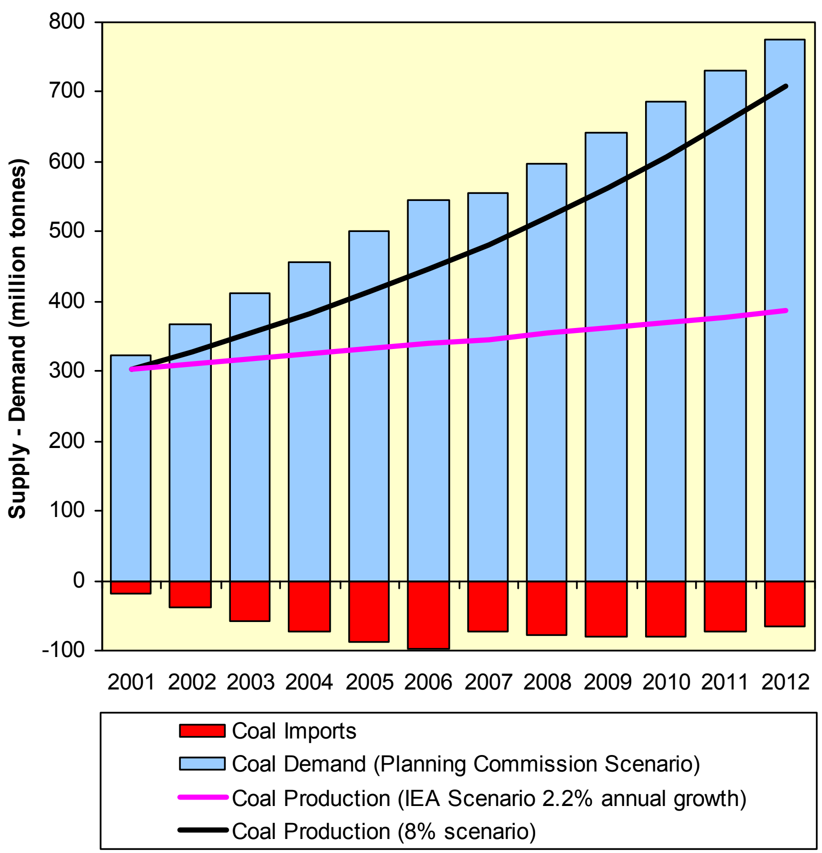
Gas supply / demand deficit to 2011 is estimate to grow to more than 30 bcm



- It is certain that the projected demand for gas is significantly greater than the forecast supply. At least in the short to medium term, any expansion in demand will need to be met through gas imports.
- The liberalisation of gas prices may result in a decrease in estimated demand levels to as the impact of the move towards market levels of gas prices is felt.
- The growing gas supply balance will be checked by production from the KG fields, but is still projected to increase to around 30 bcm by 2011.

Coal supply / demand balance depends on mine productivity and infrastructure expansion to bring coal to markets

INDIA COAL SUPPLY DEMAND BALANCE TO 2011



- There is no question that India has sufficient reserves to meet projected future coal demand. The concern here is the ability of the Indian coal mining industry to meet demand and the ability of the supporting transportation infrastructure to supply end users.
- If coal production continues to grow at the rate that was seen in the last decade, then coal production will keep place with demand. This is a tall order for the coal industry which increased production at over 3% per annum though the last 10 years, and more particularly for the transportation sector which would need to undertake a major investment programme to move 50% more coal by 2010.

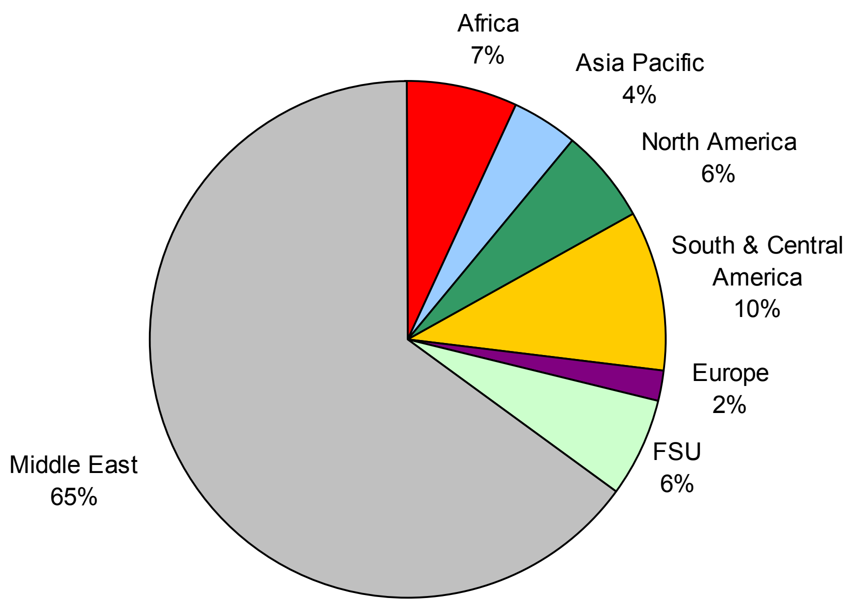
Summary

- Crude oil demand will be far in excess of domestic supply, driven largely by the transportation sector. There will be a growing dependence on imported crude oil imports and by 2010 the level of imports may reach 80% of total consumption.
- Natural gas supplies are now at a plateau level and new finds are only likely to make up for reduced production from depleting fields. Natural gas demand is already in excess of supply and India will require significant levels of imports to meet demand, which will come principally from the power sector.
- Coal reserves can meet projected demand, but it is unlikely that the coal sector in its existing form will be able to extract, process and transport coal in sufficient quantities to market demand. This will result in the importation of coal to locations distant from India's coal fields which are located in the central north of the country.
- The demand for power will require significant investment in new generation plant, not withstanding the demand-side-management effects that proper economic pricing will impose. The lower cost and faster speed of development and environmental benefits of gas fired power plant will favour increased gas use in the sector viz-a-viz imported coal, although this will be balanced by the competitive pricing of coal imports and the need for large scale investment in gas infrastructure.
- The demand for energy in India is such that there will need to be an increase in all of the major fuel supplies to meet projected energy demand. Domestic coal will not be able to satisfy the entire country's power needs, much of which will need to be met with imported coal or gas.

IX Regional Energy Supply

The major crude oil supply market is the Middle East. Some portion of crude (sweet crude) is sourced from Far East and West Africa regions.

DISTRIBUTION OF PROVED RESERVES 2001



Crude Oil and Product Supply

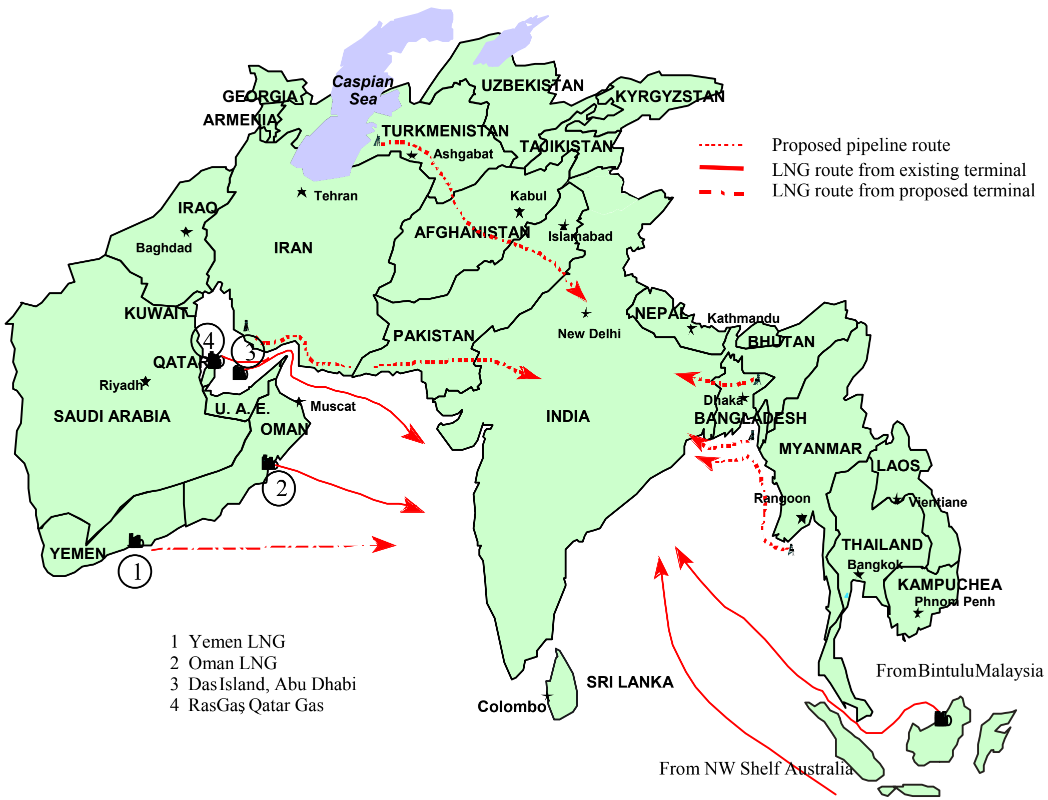
- India is heavily dependent upon energy in the form of crude oil, the bulk of which is presently supplied from the Middle East.
- In 2001 the Middle East provided 30% of the world oil output and 43% of the internationally traded world crude.
- The dominance of the Middle East region as a producer is set to increase as the region has 65% of the world's remaining oil reserves compared to only 4% in the Asia Pacific region.
- Supplies in adjacent regions, such as Africa and Central Asia are remote from India and would entail significant logistic costs.
- The dominance of the Middle East in terms of petroleum product exports is lower at 107 million tonnes against 74 million tonnes for the Asia Pacific region.

India's crude oil reserves are very small compared to world reserves.

	Thousand million tonnes	Share of total	R/P ratio
Saudi Arabia	**36.0**	25%	85.02
Iraq	**15.2**	11%	> 100
Kuwait	**13.3**	9%	> 100
United Arab Emirates	**13.0**	9%	> 100
Iran	**12.3**	9%	67.37
Venezuela	11.2	7%	63.55
Russian Federation	6.7	5%	19.12
Mexico	3.8	3%	21.73
Libya	3.8	3%	57.35
USA	3.7	3%	10.65
China	3.3	2%	19.88
Nigeria	3.2	2%	30.78
India	0.6	0.5%	17.8
Total World	**143.0**	**100%**	**40.30**
OPEC	111.8	78%	76.62
Non-OPEC	22.2	16%	13.34

Source: BP Statistics 2001

Regional Gas Supply



- There are significant gas reserves in other countries in South Asia that could be utilised to meet the Indian supply shortfall. These reserves are in:
  - Adjacent countries: Bangladesh and Myanmar
  - Middle East: notably Iran and Qatar
  - Central Asia: Turkmenistan
  - South East Asia: Indonesia, Malaysia and Australia
- Gas sources in Turkmenistan and Iran are relatively under exploited, due mainly to political difficulties and lack of gas export infrastructure.
- Other sources such as Qatar have only opened up to international markets relatively recently.

Economic factors in developing gas imports:

- **Distance to end user**
- **Price charges for gas into a pipeline or LNG liquefaction plant**
- **Transit tariffs or fee in intermediate countries**

India has only a minor share of total world gas reserves. Despite new gas finds, domestic supply will remain inadequate for meeting growing gas demand.

	Proven Reserves (tcf)	Share of total	R/P ratio
Russian Federation	**1680.0**	30.7%	83.1
Iran	**812.3**	14.8%	> 100
Qatar	**508.5**	9.3%	> 100
Saudi Arabia	**219.5**	4.0%	> 100
United Arab Emirates	**212.1**	3.9%	> 100
Turkmenistan	**101.0**	1.8%	56.6
Indonesia	**92.5**	1.7%	41.6
Australia	**90.0**	1.6%	77.9
Malaysia	**75.0**	1.4%	44.8
Kazakhstan	**65.0**	1.2%	-
China	**48.3**	0.9%	45.1
Oman	**29.3**	0.5%	61.9
Pakistan	**25.1**	0.5%	35.6
India	**22.9**	0.4%	24.5
Brunei	**13.8**	0.3%	34.3
Bangladesh	**10.6**	0.2%	27.8

Source: BP Statistics, 2001

Long-term high quality coal supplies can readily be accessed from both South Africa and Australia.

- Currently India imports 7% of total coal consumption from Australia (68%) and Indonesia (27%). Most of it is coking coal. Steam coal was imported in 2001 from Australia, South Africa and China.
- There are significant quantities of coal in the region notably in China, South Africa and Australia. Indonesia is a major exporter although it has substantially lower reserves.

	Anthracite and Bituminous (million tonnes)	Sub-bituminous and Lignite (million tonnes)	Total (million tonnes)	Share of total	R/P ratio (years)
Australia	42 550	29 540	82 090	8.3%	261
China	62 200	52 300	114 500	11.6%	105
India	82 396	2 000	84 396	8.6%	246
Indonesia	790	4 580	5 370	0.5%	58
Japan	773	-	773	0.1%	242
New Zealand	33	539	572	0.1%	141
North Korea	300	300	600	0.1%	6
Pakistan	-	2 265	2 265	0.2%	> 500
South Korea	78	-	78		20
Other Asia Pacific	227	1 600	1 827	0.2%	47
Total	**189 347**	**103 124**	**292 471**	**29.7%**	**147**
South Africa	49 520	-	49 520	5.0%	220
World	**519 062**	**465 391**	**984 453**	**100.0%**	**216**

Electrical Power Supply

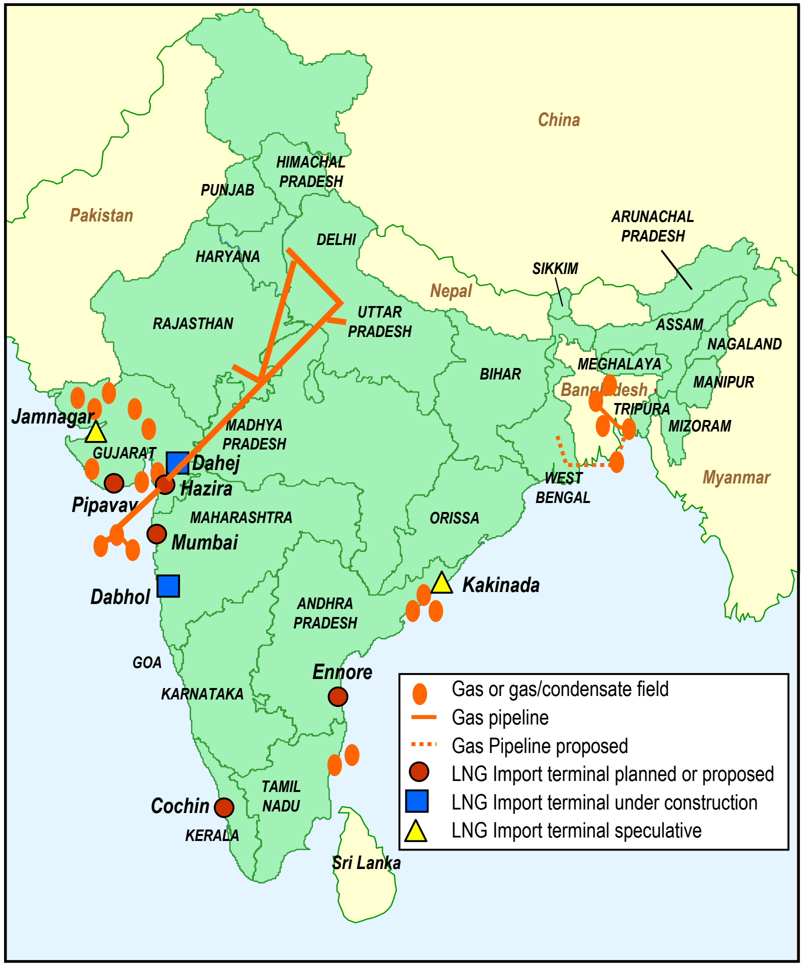
- There are substantial regional resources for hydro power generation. In addition to the potential in India, it is estimated that Nepal has a total hydropower potential of 80,000 MW and Bhutan is estimated to have a potential of 35,000 MW. These countries' current consumption is less than 1% of this value.
  - Bhutan exports 270 MW to India. The export to India will increase by 1,020 MW when the Tala power plant is commissioned.
  - There is a 50MW trade in electricity between Nepal and India, which is planned to increase to 150 MW.
- The difficulties with developing hydropower come in the financing. Such projects have extremely high upfront investments and corresponding project risks. The environmental problems associated with hydropower, in particular the flooding of large areas and the displacement of large numbers of people have made hydro power projects very difficult to finance.
- India is targeting 20,000 MW of nuclear capacity by 2020, although it is difficult to see where the funding for such projects might come from. The government does not have sufficient funds and it is highly unlikely that the multilateral sector would extend funding for nuclear power projects.

X Infrastructure Requirements to Support Regional Energy Sources

Infrastructure Development Issues

- The need for further major pipeline construction would be triggered if pipeline gas import projects take shape.
- Utilisation of imported gas would require a major trunk gas pipeline system for transportation of gas to regional markets.
- The import of LNG would require the construction of new pipelines. To support the planned LNG terminals in Gujarat, with a capacity of 12 million t/yr, 1,500 km of gas transmission grid will be needed and is being built.
- For gas use to expand as anticipated, an adequate downstream infrastructure needs to be built. GAIL estimates that investment required for the downstream sector is in the range of US$10 billion.

Potential LNG Terminals in India



Source: World Energy Map 2001 Petroleum Economist

- LNG projects require substantial volumes of gas (3.5-7.5 bcm per year) in order to gain economies of scale in process design and infrastructure requirements.
- Possible locations for LNG terminals depend largely on port facilities (14 m draft to take large vessels) and distance to the markets.

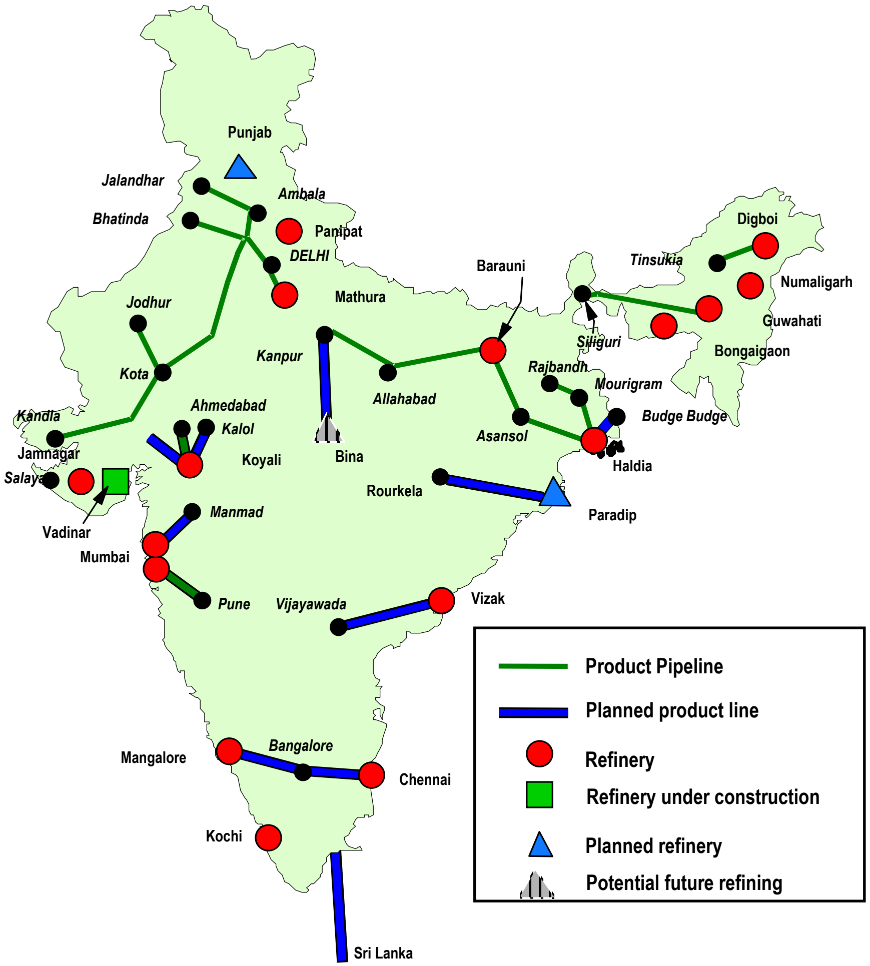
Outlook for LNG Terminals, 2003 - 2012	
Under construction	
Dabhol, Maharashtra Dahej, Gujarat Hazira, Gujarat	2003; 2.5 million tonnes 2003; 5 MT/a 2004; 5 MT/a
Planned or proposed	
Pipavav, Gujarat, Ennore, Tamil Nadu Cochin, Kerala Mumbai, Maharashtra,	2004+; 2.7 MT/a 2004; 2.5 MT/a 2004+; 2.5 MT/a 2005+; 6 MT/a
Speculative	
Jamnagar, Gujarat Kakinada, Andhra Pradesh	2005+; 2.7 MT/a 2005+; 2 MT/a

Source: World Energy Atlas, Petroleum Economist 2001

Potential Regional Gas Pipeline Projects – Each of these projects has its own intrinsic technical difficulties and, in addition, the Government of India has some difficulties in political relations with most of the supply/transit countries.

PIPELINE ROUTE	KEY FEATURES	BASIC ECONOMICS	CURRENT STATUS	ISSUES
Iran – India (Onshore)	Significant distance 2,400 km. Enters India in the western Rajastan region.	Project life 24 yrs; volume 27.4 MMcm/day; 10% discount rate. Gas price possibly less than US$3/MMBtu (no tariffs and cost of gas in pipeline included).		Crosses Pakistan
Iran – India (Offshore)	Shallow water option traverses the Pakistani waters. Pipeline lands in Kutch. Off Pakistani water option traverses difficult seabed configuration. Deep water option requires seabed investigation.	Project life 24 yrs; volume 50-74 MMcm/day.	India and Iran signed MOU in 1993. Feasibility study 1995. No Pakistani agreement to investigate shallow water option.	The shallow water option requires the cooperation of Pakistan. Political risks. Interruption of supply by Iran risk. Increase of transit fees by Pakistan risk.
Myanmar to India (Onshore - Offshore)	2,800 km, including 600km offshore.	Volume 28 MMcm/day, can be increased by 50% by extra compression. Landed gas price US$1.8-US$2.4 MMBtu (no tariffs and cost of gas in pipeline included).	Bangladesh is expected to give its approval for construction.	Risk of insufficient reserves. Reserves have to be proven up, certified and assigned to project to obtain finance. Gas lands in the Eastern part of India, a less developed market. Political risk.
Bangladesh to India (Offshore)	1,100 km. Gas lands in the Eastern part of India, a less developed market.	Volume 28 MMcm/day, can be increased by 50% by extra compression. Landed gas price US$1.0-US$1.6 MMBtu (no tariffs and cost of gas in pipeline included).		Risk of insufficient reserves. Reserves have to be proven up, certified and assigned to project to obtain finance. Critical to capture creditworthy clients in the Delhi region. Recent Krishna Godavari gas find is a threat. Technical risk
India – Oman (Offshore)	Two subsea pipelines, deep sea (3,500 m), outside Pakistan waters. Gas delivered in Kutch.	Volume 56 MM cm/day. Landed gas price linked to oil price: US$2.4/MMBtu for crude oil at US$15/bbl and US$2.6/MMBtu at US$18/bbl.		Need to establish the technical feasibility. Proof of reserves in Oman is necessary as the Oman LNG project has been executed.
Turkmenistan – Afghanistan – Pakistan – India (Onshore)	1,270 km from Turkmenistan's Dauletabad field to Northern Pakistan. Potential to expand 640 km to New Delhi.		Revived by Turkmenistan, Afghanistan and Pakistan.	Political risk.

Refinery Infrastructure



Source: International Energy Outlook 2002, Energy Information Administration

- The refining capacity currently stands at 106 MTPA. By 2010 this capacity will need to rise to over 200 MTPA to meet the demand for oil products, an increase of 90%, if all of the petroleum products required are to be refined in India.
- This would bring enormous investment requirements (estimated at $12 bn)– the Jamnagar refinery with a capacity of 27 MTPA cost US $3.5 bn to build.
- There are a number of proposed refinery projects in India, mostly concentrated on the east coast.
- There is, however, significant refining over-capacity in the Asian region, notably in Singapore.
- The Indian government intends to pursue a policy of energy self-sufficiency. In this context, 90% of middle distillates demand is intended to be met from domestic supply.

The share of domestic shipping companies in India's sea borne trade is going down. This results in loss of foreign exchange along with an increase in the freight cost.

Industry Size

- The existing port structure is insufficient to meet India's energy needs in terms of ship-borne imports. There are major bottlenecks with high ship turnaround times and relatively low output per berth.
- The Indian merchant marine is small (at around 500 vessels) in relation to the target of carrying 50% of trade on nationally owned vessels. The age profile of India's fleet shows that 30% of the fleet is more than 15 years old, therefore more or less due for scrapping
- The 9th plan targeted the merchant marine to reach 9 million gross registered tonnage (GTR). However, the industry reached only 6.9 million GTR in November 2001. Due to heavy corporate taxation, the shipping industry finds it difficult to add new ships to its fleet.

Commercial Aspects of the Shipping Industry

- Indian net oil import bill is estimated to be US$15bn in 2000/01 against US$10 bn in 1999/00. The freight cost represents 3% of this, or US$0.4bn.
- US$3.6bn was paid to foreign ships for all trade, including crude oil, as freight costs in 2000. The percent of overseas trade carried by India's ships slipped over the last ten years from 40% to 30%. These statistics indicate that the Indian shipping industry could increase its market share which currently goes to foreign ships. Although these are aggregate numbers, the trend is reported to be similar for the oil industry.
- An additional concern for the Indian shipping industry is the changing traffic pattern brought by reforms in the oil industry. We refer specifically to the impact this has had on the type of vessels servicing India's growing demand. IOC has finalised oil purchase contracts on a cif (cost, insurance, freight) basis from the Gulf, on very large vessels (type VLCC) that India does not own at present.
- The growth of Indian shipping industry is also limited by the decline in its fleet strength, undue high taxation of the industry and the need to upgrade port facilities to be able to handle large vessels, which could for example move more efficiently crude and petroleum products

India needs foreign capital in order to meet the financing requirements associated with covering the energy supply demand gap.

SIZE OF FINANCING REQUIREMENTS	DOMESTIC SOURCES OF FINANCE
Estimated financing requirements up to 2012 (end of 11th plan) to undertake investment in order to enhance energy security of supply are: - Refining: US$12bn to increase capacity from the existing 106MTPA to the estimated 200MTPA - Gas related: US$9 bn for LNG and pipelines over the next ten years - Coal industry: US$0.4bn per year (in line with recent annual expenditure) - Power sector: US$250bn for 100,000MW new capacity and associated infrastructure over the next ten year period (end of 11th plan).	**Equity participation** for energy projects could be provided by: - Domestic developers mobilising their own stock and stock market funds - Public and Semi-Public Utilities such as GAIL - Other Institutional Investors The estimated capacity of domestic equity investors is about US$ 1bn. **Debt** can be provided by: - Commercial Banks - Financing Institutions - Domestic Bonds The estimated capacity of Indian financial institutions is to provide US$ 5bn as debt.

XI Security of Supply Issues

The Energy Security Concept and what it means for India

Security of Supply

- For India, as with most countries, access to competitive energy supplies depends on access to the energy available in the world trading system. It is protection of this trading system, rather than specifically the energy component, that is critical to security. That protection depends on international co-operation, alliances, the support of the UN and in the last resort the military participation of the US. For India as with most of the world, the dependence of the US on international energy supplies is a guarantee of their security.
- As in most developing countries, in India security of supply means security of expanding supply in line with economic growth. Liberalization of the energy sector to achieve lower costs may compound the difficulties that under-funded state monopolies face when investing to expand due to even lower revenues associated with lower electricity prices.
- Inviting international investors to take part in expansion of India's energy infrastructure is part of the broader modernisation of the economy. In India, the demand for energy will result in the need for increased energy imports, higher investment in import infrastructure and integration into regional and international markets for trade and investment. As in developed countries, imports and investment in domestic infrastructure are part (although not all) of the solution to securing supply.

There are several types of security of supply risks

Physical Security of Supply

- Permanent physical disruptions occur when an energy source is depleted or production is stopped. The consequences of such actions needs to be viewed in terms of dependence and environmental objectives. Within this category are three types of risk:
  1. Technical Risk – accidents or catastrophe putting supply facilities out of action
  2. Failure to mobilise long-term supplies – where demand outpaces supply
  3. Political events – disruption to supply

Economic Risks

- Economic disruptions are caused by the erratic fluctuations in the price of energy products on world markets. The rise in fuel prices creates monetary and trade imbalances which are harmful to a country's economic health. Geopolitical considerations, such as OPEC, the recent difficulties in the Middle East, and the embargo on Iraq are major factors, although defining the impacts are difficult.

Social Risks

- Petroleum is vital for the functioning of an economy and any disruption is likely to lead to social demands, if not social conflict. The instability of energy supplies, whether linked to erratic fluctuations in prices, relations with producer countries or a chance event may cause serious social disruption.

Environmental Risks

- Environmental disruptions may arise through damage to the environment caused by the energy chain whether accidentally or as a result of emissions.

Differences among primary energy source security issues

The supply of gas, and to a lesser extent coal, is different from that of oil. The fungible nature of oil leads to a focus on price rather than non-availability of supply. For gas, the focus is more about avoiding physical shortages rather than price shocks, and the global dimension is less prominent. Coal occupies an intermediate position – its availability is linked to the means of getting it to the markets rather than non-availability of supply in a fairly stable price environment.

OIL SUPPLY	GAS SUPPLY	COAL SUPPLY
Global oil market exists. Oil is a fungible commodity traded in international markets. Markets are liquid.	Gas markets are regional. Gas supply is regulated. Gas supply is a direct producer to consumer relationship.	Coal markets are global. Coal is a fungible commodity traded in international markets. Markets are partly liquid due to limited trade and oligopoly pricing.
Oil pricing is set by international markets for spot and future volumes.	Pricing is long-term (maybe changing to short-term but in developed markets).	Coal pricing is set by international markets for spot and future volumes.
Oil supply disruptions have been political (cartel driven).	There have been no major disruptions of gas supply.	Local supply disruptions have occurred due to political activity.
Oil is not easily substitutable (provides 60% of transport fuel where substitutes are lacking). The sector is politically sensitive.	Gas is substitutable – gas companies work on maintaining supply	Coal is substitutable – coal suppliers work on maintaining supply

Oil Supply Security Issues for India

OIL SUPPLY SECURITY ISSUE
• India is highly dependent upon oil imports, which are concentrated in supply from the Middle East. This is the logical source of supply given that it is the cheapest source of crude oil globally, and the closest to India. As a consequence, physical supply to India is concentrated through the Strait of Hormuz, which could be a point of constriction should major conflict break out in the region. • However the real risks are economic rather than physical. There is adequate global oil supply even if Middle East supplies are restricted – although historically this has not occurred even at times of intense conflict, e.g. the Iran – Iraq War, the Gulf War. The major risk to India is one of higher crude oil prices and of volatility in oil prices. • India at present lacks a strategic oil reserve to act as a buffer stock against short-term shortages and market spikes. India has operational reserves for only 30 days.
MEASURES TO INCREASE OIL SECURITY
• As the dependence upon imported crude oil increases it will be prudent to undertake several measures to mitigate the potential security impacts 1. Increase the diversification of sources of crude oil imports. 2. Invest in equity stakes in crude oil reserves overseas to provide a natural hedge against volatility. 3. Establish a strategic oil reserve to dampen short term volatility. The issue here would be who would pay for this reserve, the government or the oil companies. 4. Continue to work on the enhancement of domestic supply by encouraging international oil companies to explore in India. 5. Demand side measures – manage demand through pricing and fiscal measures to optimise the domestic use of fuel. For example the use of gasoline in transportation could be encouraged to bring the diesel/gasoline usage into balance and reduce the export of refined products.

Gas Supply Security Issues for India

GAS SUPPLY SECURITY ISSUE
• The key security issue for gas is that of securing long-term physical supply at appropriate pricing. An allied issue is the concern of concentration of supplies due to infrastructure limitations, and the potential for physical disruption due to technical failure. • Pricing will need to be assured against substitute fuels in order to ensure that consumers do not move away from gas fuels and jeopardise contractual structures. • Gas should be an economic long-term energy source with environmental benefits, but will not be competitive against subsidised competing fuels.
MEASURES TO INCREASE GAS SECURITY
• There are adequate gas supplies in the region. The critical issue is the Indian consumer's ability/will to pay for gas when other fuels are available at lower cost. For gas supplies to be secured there will need to be an economically sound, transparent fuel pricing structure, free from government interference, and a clear, unbiased regulatory environment. There are some key measures that can be taken: 1. Encourage gas export programmes with neighbours, especially Bangladesh. 2. Ensure gas import contracts have linkages with competing fuels to sustain competitiveness. 3. Power prices (the major gas use) should be economically based and detached from government interference. While subsidised power prices prevail, the power sector will be unable to support gas supply contracts, e.g. Enron at Dabhol. 4. Continue to work on the enhancement of domestic supply by encouraging international oil companies to explore in India. 5. Demand side measures – ensure that imported gas is used where it is most economically efficient, i.e. not in fertiliser manufacture or sponge iron. Pricing signals should discourage the use of gas in uneconomic uses.

Coal Supply Security Issues for India

COAL SUPPLY SECURITY ISSUE
• As with gas, the key issue for coal is in ensuring long-term physical supply. India has substantial coal reserves but has so far been unable to attract additional investment necessary to increase and sustain higher levels of production and to improve the quality of the coal. • Transportation remains a major bottleneck for the supply of coal. • Internationally, reserves of coal are huge and there is no likelihood of global coal shortages. However, the imported sources of high quality coal are relatively limited, Australia and South Africa being the two major potential suppliers. • Coal is significantly more polluting than other sources of energy and future environmental regulation may impose significant costs on coal usage.
MEASURES TO INCREASE COAL SECURITY
• In order to increase domestic coal production, the government will need to reform the Indian coal sector to make private sector investment attractive and improve production facilities. • The transportation of coal through the railways will remain constrained due to the huge cost multi-layered government involvement in the sector. However, the economic pricing of coal transportation will enhance the competitiveness of local coal. • As with gas, the security of long-term coal imports will be most dependent upon the establishment of transparent energy pricing policies and even-handed regulation. • New coal-fired plants will need to be equipped with flue gas desulphurisation or other emission reducing equipment.

Power Sector Supply Security Issues for India

POWER SECTOR SUPPLY SECURITY ISSUE
• The power sector is unable at present to meet demand and the situation continues to get worse. The sector suffers from inadequate generation capacity; insufficient transmission and distribution infrastructure; inappropriate pricing; mismanagement; theft; and government interference. Clearly the situation needs to be radically improved just to ensure supply at the present. • The transmission systems are regional and in most cases lack the interconnection capacity to wheel power through the regions to meet capacity bottlenecks, although efforts are underway to expand regional power flows. • There is little prospect at the present, with the history of the Dabhol saga fresh in potential investors minds, of mobilising foreign investment for generating plant let alone transmission or distribution infrastructure.
MEASURES TO INCREASE SUPPLY SECURITY
• There needs to be radical reform of the power sector to put it on a commercial footing. Economic reform of pricing is a necessary precursor, as is restructuring and the introduction of a proper regulatory regime. The removal of the power sector from government ownership is critical. The sector needs to become more investor-friendly to secure badly needed investment capital. • Demand side management will reduce the need for new capacity additions by shifting load from peak to off-peak through differentiated tariffs, and energy savings on the supply side are possible too, e.g. by increasing the thermal efficiency of a power plant in India from 29% to 35%-42%. • Interconnections with adjacent power-rich states such as Nepal should be encouraged. Nepal has hydroelectricity potential of 80,000 MW and Bhutan 35,000 MW.

Alternative Energy Supply Security Issues for India

ALTERNATIVE ENERGY SUPPLY SECURITY ISSUE
• Hydropower potential is significant but it will be difficult to raise investment resources. • Difficulties in financing nuclear generation. • Renewable energy is relatively costly, and will be difficult to justify in a developing country such as India which has many calls on very limited investment capital. • Alternative gas sources such as coal bed methane are commercially unproven, other sources such as gas hydrates do not have established exploitation methods.
MEASURES TO INCREASE SUPPLY SECURITY
• With appropriate screening and environmental assessments it should be possible to develop a limited amount of new hydropower. More immediate sources of hydropower would be from Nepal and Bhutan. • Monitor the technological developments in renewable energy, and develop government policy to encourage development of cost-effective resources. • Encourage the development of alternative gas exploitation via assistance from technologically advanced nations such as the US, which has the resources to undertake the necessary research and development. • The role of nuclear worldwide has resurfaced as one way of diversifying a country's energy mix and hence of ensuring security of supply. The economics of this industry are still unfavourable compared with coal or gas and therefore in the absence of strong political will (to ensure security of supply and reduce carbon emissions) it is unlikely that nuclear generation can gain more market share.

Liberalisation of India's energy sector to achieve lower costs may add to the difficulties which under-funded state monopolies face when investing to expand. Therefore, a comprehensive policy is needed to place the sector an a commercial basis and to encourage private sector investment.

ENERGY SECURITY OF SUPPLY IN INDIA MEANS:

- **Closing the energy gap between domestic demand and supply**
- **Expanding supply in line with the country's economic growth**
- **Providing energy at the lowest overall cost possible**
- **Diversity of supply**

This implies increasing energy imports and investment in domestic infrastructure, including import infrastructure.

XII Policies to Support Energy Security

Energy Planning

- Energy Planning in India is undertaken by the five government entities involved in the sector; Ministry of Power, Ministry of Petroleum & Natural Gas, Ministry of Coal and Department of Atomic Energy and is implemented through the cabinet and the Planning Commission. Each Ministry undertakes it's planning in the form of a five-year plan. The 10th Plan began in 2002 (2002-2007).
- There is little co-ordination between Ministries, except at the time of preparation of the five-year plan, and even then it tends to be an aggregation of five-year plans rather than a strategy for the overall energy sector..
- In the face of the Indian tendency to concentrate power at the centre, in terms of energy planning it means that there is no overall optimisation of energy provision. Given that India will become increasingly reliant upon imports there is a need for a more decentralised framework for ensuring that least cost options are identified and that there is sufficient security of supply.
- There is a need to better co-ordinate energy planning in order to make the right choices in terms of optimal supply. Achieving an optimal fuel mix requires an integrated approach to energy management.
- Energy prices need to be set on a proper economic footing so that consumers make rational choices between fuels and wastage is eliminated.
  - In terms of petroleum products, this means pricing and import parity level.
  - Domestic gas should be priced against competing fuels.
  - Electricity tariffs should cover the economic cost of supply to each consumer group. Electricity tariffs should also incorporate time of day charging to better use the existing resources.

Energy Policy and Security of Supply

- The Government of India has long been concerned with energy security and the management of the sector to avoid disruptions. The mechanisms commonly used to do this have been quantitative restrictions in the level of imports and exports.
- In the oil sector this has manifested itself in the channelling or "canalization" of crude imports through a public sector company – Indian Oil Company, although this policy has recently been abandoned.
- Price fluctuation was dealt with using the Administrated Price Mechanism (APM), a pool which was used to even out price fluctuations, setting a long-term price and paying into a pool when the crude purchase price was low and paying out from the pool when the price was high.
- There are several important aspects to energy security that should be considered by the Indian government. It is important to understand that domestic self-reliance is not a security measure and that imports are not a measure of a security problem, indeed diversity and flexibility of supply are the main security issues.
- The role of the government in providing energy security should be to :
  - Define acceptable level of risk.
  - Encourage investment and trade.
  - Ensure effective regulation and efficient pricing.
- Security is about minimising and managing risks, not maximising domestic supply, which in many cases for India would increase pressure on overworked infrastructure and reduce supply reliability.

Crude Oil and Product Supply

- India is heavily dependent upon energy in the form of crude oil, the bulk of which is presently supplied from the Middle East. These supplies are transported through the straits of Hormuz to ports on the west coast of India.
- The need to import crude oil has a very significant impact on the balance of payments. During the Gulf War, India's oil import bill was around $3.5 billion. By 1995/6 this bill had risen to $9 billion and in 1998 was around $11 billion.
- There are several policy options open to India to increase oil security:

1. Establish a strategic oil reserve – presently an operational reserve of only 30 days is mandated. The GOI announced in 2002 that proposal were examined to set up reserves at five locations to provide an additional 15 days of inventories.
2. Diversify sources of oil imports – this will be difficult given the concentration of supply in the Middle East region. Diversification to other sources will necessarily incur significant expense.
3. Invest in equity oil abroad – the investment in overseas equity oil provides a natural hedge against oil price movement. ONGC Videsh has been formed to invest in overseas production and thus far has invested in Kazakhstan, Sudan, Algeria, and Iran.
4. Enhance domestic supply – much effort has been expanded in developing and marketing the New Exploration Licensing Policy (NELP) although thus far with little international interest. India is not considered a major oil province and is likely to continue to find it difficult to attract the interest of major league oil companies.
5. Promote efficient pricing and use of oil products through a comprehensive domestic energy strategy.

Energy trade is good for the region

- Regional energy trade can go a long way to enhance energy security in India, and also to improve the balance of regional trade.
- India could provide Bangladesh with the lowest supply cost market for its gas, enabling Bangladesh to maximise the value of the resource. It would also help to offset the trade balance with India, which at the moment results in large cash outflows to India from Bangladesh.
- Similarly the sale of hydroelectricity by Nepal and Bhutan to India would provide a market for energy that would otherwise remain unrealised by indigenous demand, and also would provide a stream of foreign currency to these countries that would offset trading imbalances with India.
- The construction of new gas pipelines will make it possible to import gas from Iran / Turkmenistan or from Myanmar, thereby improving security of supply by diversifying geographic sources of supply. These pipeline will not only meet the demand in the target markets (India) but will also meet demand in transit countries (Pakistan), thus increasing the economies of scale and making the pipeline economics more attractive. The pipelines can also bring transit fees, for example to Bangladesh.

XIII Energy Supply Scenarios and Impact on Energy Security

Key factors affecting the energy security of supply are the GDP growth and the crude oil price which have a direct influence on the size of the demand/supply gap that has to be met

- In assessing the impact of key factors on the energy security of supply, we considered that **the gap between energy demand and supply is a measure of the security of supply in India**. Several key factors can affect:

  A. The size of this gap.

  B. How can this energy gap be met.

- We undertook a scenario analysis focused on estimating the impact of several key factors affecting energy security of supply (i.e. energy gap) in three principal dimensions:

  - Level of overall consumption;
  - Level of imports necessary to meet demand;
  - Impact on foreign exchange.

- To analyse the evolution of the energy supply / demand gap (point A above) we considered that the growth of GDP and crude oil price will have the greatest impact on this gap over the next ten years. The following scenarios have been analysed:

	Scenario	Key Factors
1.	Stable economic growth	• Long-term sustained GDP growth 5.4% • Long-tern stable crude oil price US$20/bbl
2.	Recession	• Low GDP growth 2% for three year followed by long-term sustained GDP growth 5.4% • High crude oil price US$30/bbl followed return to long-terms stable crude oil prices USD20/bbl
3.	High economic growth	• High GDP growth 8% • Long-term stable crude oil price US$20/bbl

Domestic energy sector policies, geopolitical factors, environmental regulation and attractiveness of the India power sector to foreign investment have a direct impact on how the demand/supply gap can be met

- Several scenarios can affect the way the energy supply / demand gap is met (point B). These scenarios represent a variety of possible energy sector political and financial actions and they are each characterised by key factors – a summary of these is presented below.

	Scenario	Key Factors
4.	Administered Gas Pricing Mechanism	• Gas Price As Is: US$2.5/MMBTU • Gas Price Increased: US$3.5/MMBTU
5.	New Gas Finds	• No Finds • Small Gas Finds: 3 tcf / 84 bcm • Significant Finds: 7 tcf / 196 bcm
6.	IPP Investment in New Capacity	• No Power Sector Restructuring: 5% IPP investments • Power Sector Restructuring: 15% IPP investments
7.	Coal Price (mine mouth)	• Continued Public Ownership: US$21/tonne • Privatisation: US$25/tonne
8.	Coal Production Profile	• Benign Environmental Regulation: 5% • Increased Environmental Regulation: 3%
9.	Gas Import	• Iran – Pakistan – India: 10 bcm/year • Turkmenistan: 15.3 bcm/year • Bangladesh – India: 10.2 bcm/year • Myanmar - Bangladesh – India: 10.2 bcm/year

1. Stable Economic Growth Scenario

Assumption

- India had a sustained annual growth rate of 5.4% despite worldwide economic slowdown over the last two years. Economic growth is likely to continue at the 2001/02 level for the next ten years to 2013.
- The crude oil price is assumed to be stable on a long-term basis at US$20/bbl. Coal imports are assumed to continue at the current price of US$29 / tonne. Gas imports will be available starting with 2005 at a cost of no less than US$3.5/MMBTU.
- Energy intensity will remain constant over the next ten years and in line with recent figures (IEA Statistics) of 693 toe needed to generates $1 million of GDP.
- Primary energy demand will grow in line with GDP. 30% of the demand will be met from imports, based on the assumption that the Indian energy sector will meet up to 70% of the increasing demand.

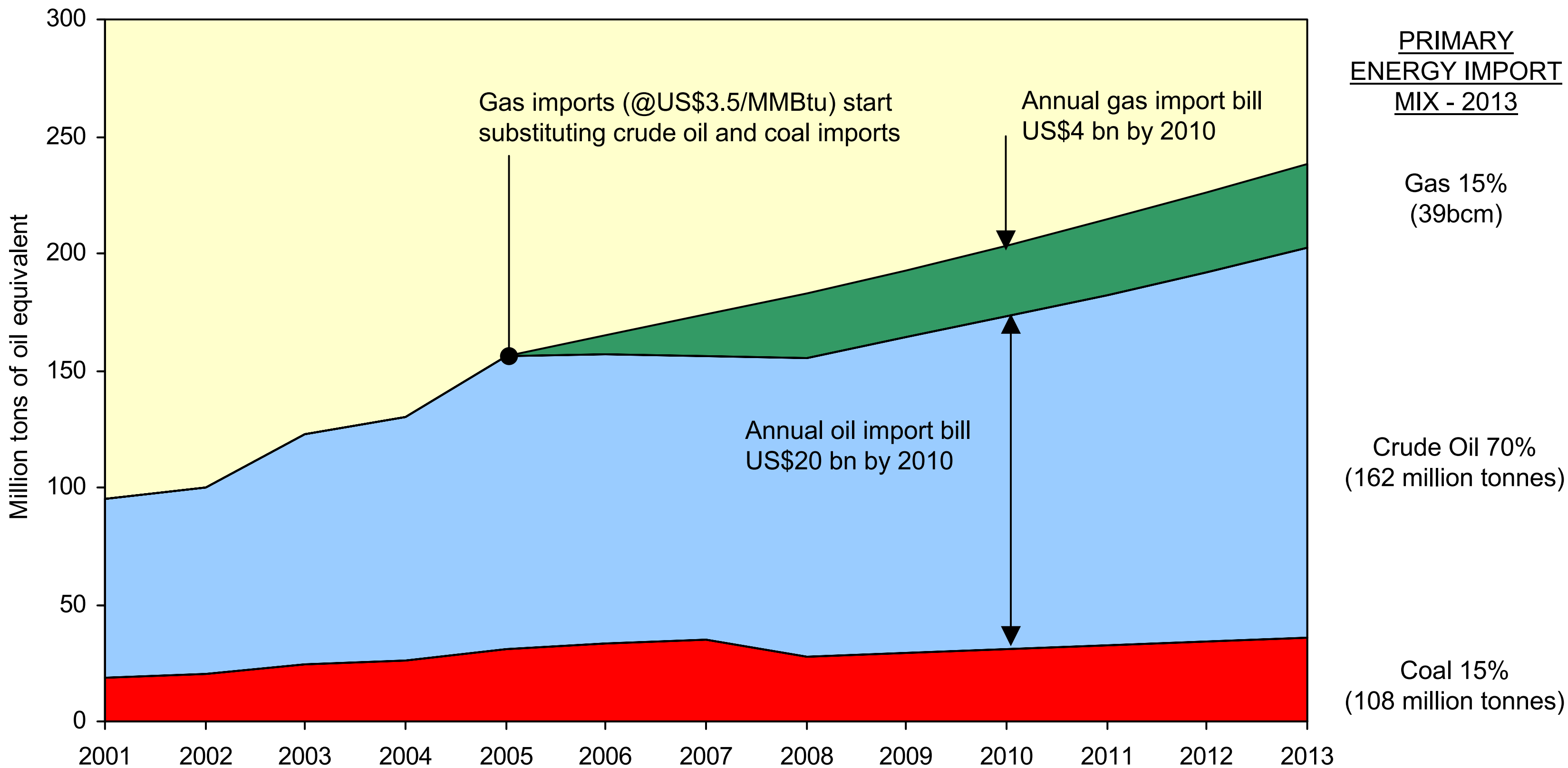
Impact on the Energy Demand / Supply Gap

- Primary energy imports will continue to grow. The primary energy imports mix will continue to be dominated by crude oil imports even though a slight decline is expected once India starts importing gas, which was assumed to happen no sooner than 2005.
- Gas imports are estimated to reach 39 bcm in 2013.
- The primary energy trends estimated under this scenario will make necessary the importation of gas and crude oil. The foreign exchange required in 2013 will be approximately US$31bn, or double the current total energy import bill.
- The immediate implications of this scenario in meeting the energy demand in 2003 on the balance of payment is estimated at US$1.8 bn. This represents an extra 14% to the existing import bill (US$12.5 bn in 2001/02 [1]). Considering India's foreign exchange reserves of US$72bn (Jan 2003), the incremental import bill in 2003 could reduce the reserves by 2.5%.
- Increased crude oil imports will have to be supported by adequate shipping and port infrastructure to ship effectively the 162 million tonnes forecasted for 2013.

1 India Profile, Composition and Direction of Trade, www.searched.org/newssaarcnet/countryprofile/India22.htm

The current situation of heavy dependence on international crude oil imports is likely to continue at the same level under the stable economic growth scenario

Scenario 1 - SUSTAINED GDP GROWTH 5.4% AND LONG-TERM STABLE OIL PRICE US$20/bbl



2. Recession Scenario

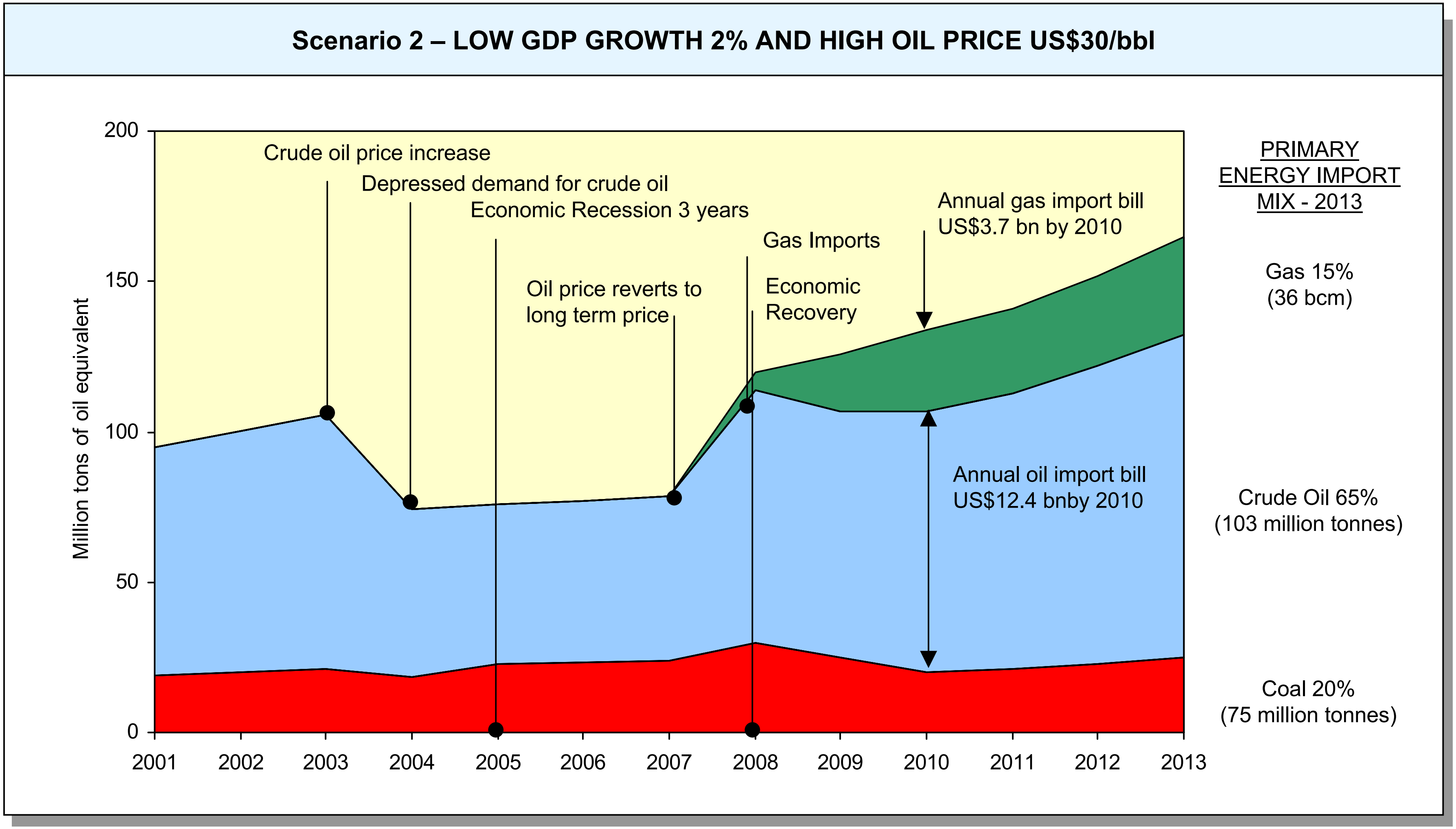
Assumption

- Economic growth is slowed down for a period of up to 3 years, starting with 2005. This coincides with a significant increase in crude oil price to US$30/bbl. Consequently the demand for crude oil is depressed.
- Oil price reverts to the long-term price of US$20/bbl by 2007.
- The economy recovers in 2008, thereafter following a path of sustained 5.4% growth for the rest of the period.
- Energy intensity will remain constant over the next ten years and in line with recent figures (IEA Statistctics) of 693 toe for US$1 million of GDP generated.
- Primary energy demand will grow in line with GDP. On an aggregate basis, total primary energy requirements will be met by domestic sources and imports in the ratio 70:30.
- Coal imports are assumed to continue at the current price of US$29 / tonne. Gas imports will be available starting with 2005 at a cost of no less than US$3.5/MMBTU.

Impact on the Energy Demand / Supply Gap

- Primary energy imports will drop during the period of high crude oil price and economic recession by almost 30% and recover to the 2003 levels by 2008. Thereafter, primary energy demand grows at a rate similar to GDP, reaching a total of 548 mtoe in 2013. About 164 mtoe of this is sourced from imports.
- During the recession, coal will maintain its predominant position and therefore it is likely that coal imports will continue.
- Gas imports will be slower to materialise and are estimated to begin in 2008. It is likely that fuel substitution will occur, with crude oil and coal reducing their share in the primary energy imports mix.
- Gas imports are estimated to reach only 27 bcm in 2013. Imports alternatives will remain the same, i.e. LNG and gas pipeline.

A recession is likely to maintain the attractiveness of coal



3. High Economic Growth Scenario

Assumption

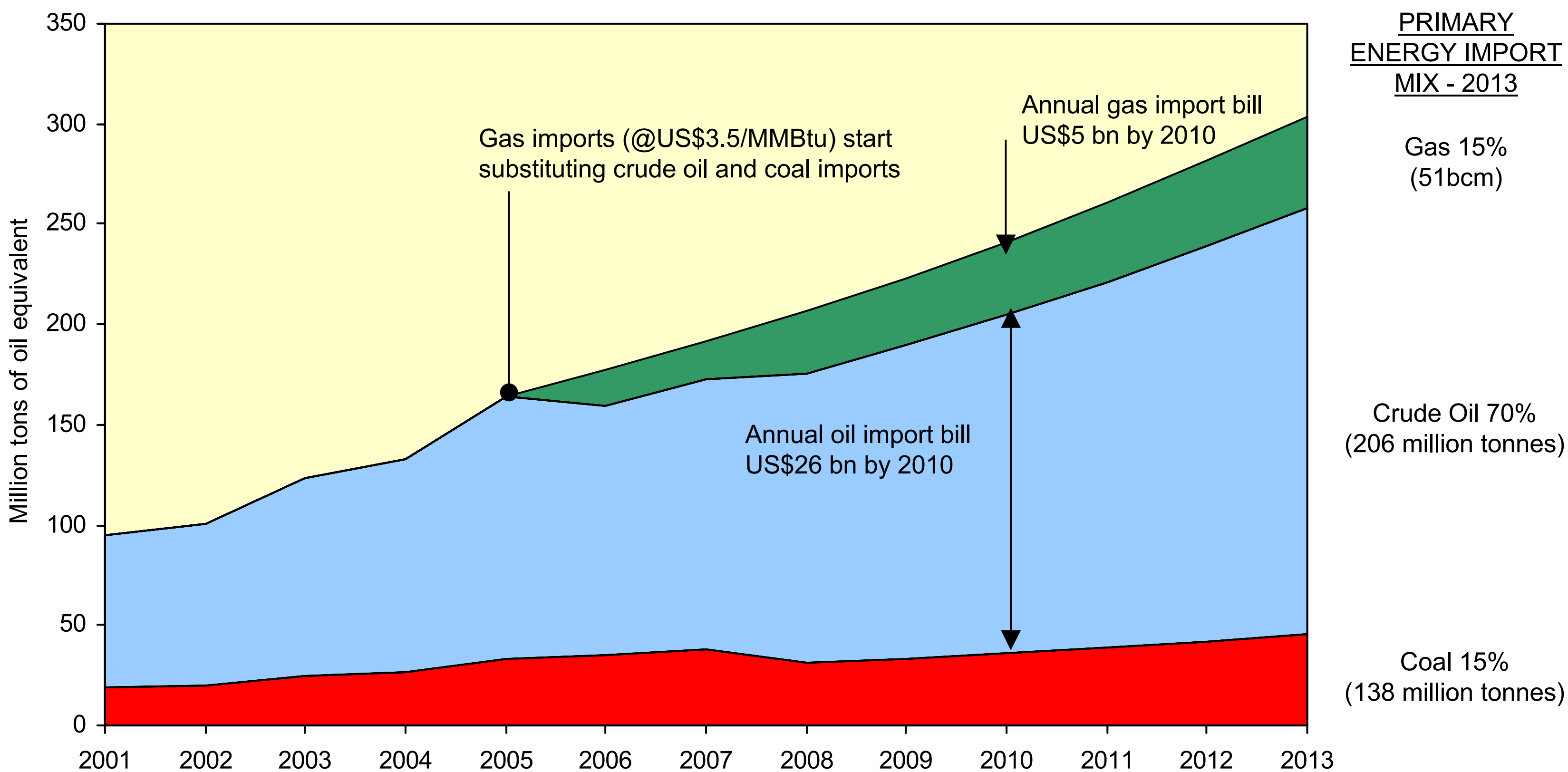
- Economic growth is estimated to follow a long period of sustained growth at 8% per year.
- The crude oil price is assumed to be stable on a long-term basis at US$20/bbl. Coal imports are assumed to continue at the current price of US$29 / tonne. Gas imports will be available from 2005 at a cost of no less than US$3.5/MMBTU.
- Energy intensity will remain constant over the next ten years and in line with recent figures (IEA Statistics) of 693 toe for US$1 million of GDP generated.
- Primary energy demand will grow in line with GDP. The higher primary energy requirements will trigger a need for increased imports. These are assumed to raise to 40% toward the latter part of the forecasted period.

Impact on the Energy Demand / Supply Gap

- The primary energy imports will continue to grow. The primary energy imports mix will continue to be dominated by crude oil imports though its share will decline once India starts importing gas, which is estimated to happen no sooner than 2006.
- A period of high economic growth can stimulate the need to restructure the coal industry. This process is likely to be slow but it can result in increased domestic production and a higher coal price. Consequently, the share of the coal in the mix of primary energy imports could be reduced from the current 20% to 15%.
- Gas imports are estimated to reach 51 bcm in 2013 due both to the energy consumption increase and the change in the energy mix in the favour of gas. This prospect can trigger an intensification of exploration.

The high economic growth will have to be supported by an extra 25% increase in foreign exchange compared to the long-term scenario

Scenario 3 - HIGH GDPGROWTH 8% AND LONG-TERM STABLE OIL PRICE US$20/bbl



3. High Economic Growth Scenario (continued)

Assumption

- The primary energy import trends estimated under this scenario are an increase in the importation of gas and crude oil. The foreign exchange required in 2013 will be approximately US$40 bn, or 2.5 times the present energy import bill.
- The implication of a high growth rates will be that capital expenditure will grow in importance while that of fuel imports spending decreases as the need to put in place the necessary infrastructure can be critical in maintaining the supply / demand balance.
- It is likely that in the case of high crude oil price scenario, some fuel substitution will take place. This will have a positive impact on the balance of payment (or foreign exchange reserves). Imports of cheaper natural gas from nearby countries will support this benefit as well an ensuring diversity of energy supply. If gas is imported at US$3.5/MMBTU to substitute 10% of crude oil consumption, saving of around US$30 million could be achieved in 2005, which may increase to more than US$40 million in 2011.

Impact on Energy Policy

- Petroleum product demand, especially for transportation, will grow in line with GDP growth. As in the long-term scenario, the same factors are likely to determine the trend of accelerated growth in gasoline demand – migration towards more stringent clean fuel environmental specifications by the end of this decade and dismantling of APM on transport fuel products.
- The planned expansion for the next ten years may have to be complemented by a grassroot refinery, even though this will be dependent on the evolution of the market with respect to the dismantling of APM for transport fuels. The dismantling of APM will put pressure on the refineries' gross margin due to the competitive pressure. The possible grassroot initiative are estimated to be installed by 2015/16 for an additional 25 million tonnes of annual capacity. The most likely projects are IOC in Paradeep, Orissa and HPCL in Bhatinda, Punjab. Over the forecasted period of time to 2013, the planned expansions will be sufficient to maintain a rough balance between supply and demand.

4. Administered Gas Pricing Mechanism Scenario

- The level of gas demand is affected by its pricing. As it stands now, domestic gas is cheaper than the probable price of any type of imported gas: US$2.5/MMBT vs. US$3-3.5/MMBTU. Therefore, the key factors affecting the level of gas demand are related to the future of the APM for gas.
- The forecasted gap in gas supply will reach 54 bcm by 2013. Should this gap be met entirely from imports, the total gas bill can reach US$6 bn in 2013.
- The projected shortfalls in gas supply in the north west, western and southern regions of India will only be met in the short to medium-term by LNG supplies. In the long-term, the supply of gas through (or around) Pakistan may become a possibility to support demand in the north west of the country. The general pattern of economical development that emerges for the northern, western and southern regions is one of pipelines carrying gas inland to consumers from LNG hubs.
- The new gas discoveries in Andhra Pradesh will naturally support the meeting of energy demand on the eastern coast. Even at current prices, these new gas finds will not be economical if transported by pipe to the western coast. Plans to serve the western markets from the Southeast require substantial capital investment in transport infrastructure and require considerable time for project development, planning and execution, which could erode any pricing and timing advantages the KG field gas has presently. There will be a rationalisation of gas prices, the western regions with higher gas prices than the eastern regions, if coal supply remains stable and serves the eastern region at competitive prices.
- The impact of gas pricing on power demand can be analysed by looking at the planned power plants that are designed to burn gas or could switch to gas if the price is attractive. If coal is priced below market prices, gas-fired power would be competitive at US$3-3.5/MMBTU in the regions close to the coal mines, e.g. on the east coast and northeast India. If coal reaches import parity prices, gas would be affordable at US$4/MMBTU across India.

5. New Gas Finds Scenario

New Gas Finds

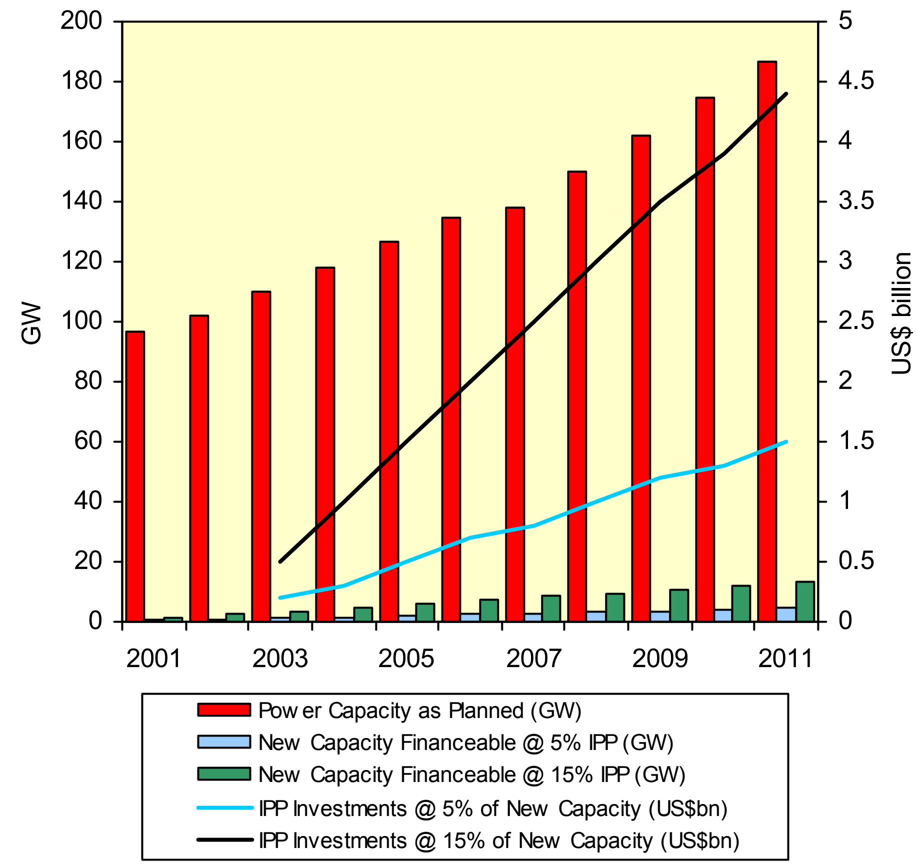
- The key factor affecting the new gas finds and their ability to meet the forecasted gas demand gap is the size of new potential gas finds.
- The new gas discoveries in Andhra Pradesh (Krishna Godavari basin) with reserves estimated at 20 bcm will come in support for meeting the energy demand on the eastern coast.
- The impact of new gas finds on foreign exchange is limited in the context of the forecasted significant growth in gas consumption. We developed two scenarios for the size of the gas finds to assess their impact on the gas balance and foreign exchange reserves.
  - Continued small gas finds (< 84 bcm)
  - Major gas finds (> 84 bcm), in particular the Krishna Godavari with estimated reserves of 196 bcm
- If gas consumption reached 75 bcm by 2010 and the domestic gas production remains at the current level, the gap between domestic demand and supply will deepen to the level of 50bcm. A large discovery such as Krishna Godavari will improve this balance significantly. We assumed that production will start at the new gas find in Krishna Godavari in 2005. The production could reach a plateau in 3 years at 7 bcm per year to fuel a 1,000 MW CCGT plant. Under this scenario, imports could be reduced by 18% compared to the scenario whereby only small gas reserves are discovered. This is equivalent to a foreign exchange saving of around US$2 bn.

6. IPP Investment in New Capacity Scenario

Power Sector Restructuring – IPP Investments

- The impact of the state of the power sector (i.e. the financial condition of the SEBs) upon its capacity to meet increasing demand is significant. The SEBs' poor financial situation, due to subsidised electricity tariff rates for agriculture and losses arising from theft and technical inefficiency, has been the main obstacle in generating new capacity. SEBs cannot afford to generate the power themselves or to buy from IPPs.
- The scenario that will have the most impact upon reducing the demand/supply gap is the implementation of restructuring of the power sector. If such a restructuring takes place, more IPPs will become viable. We assumed that IPP investment can raise up to 15% of the total new generating capacity needed in India to meet the demand. The base case scenario is represented by no power sector restructuring, in which case only 5% of this new generating capacity could be attributed to IPPs.
- If no restructuring takes place, assuming that only 5% of new capacity additions can be built as IPPs, the power generating deficit will be reduced by 4.5GW between 2005 and 2011 at a cost of US$1.5 bn. Should more IPP investment be available (15%), the generating capacity deficit can narrow by 14.5 GW at a cost of US$4.4bn.

IPP INVESTMENT (FDI)
IN NEW CAPACITY ADDITION PLANNED

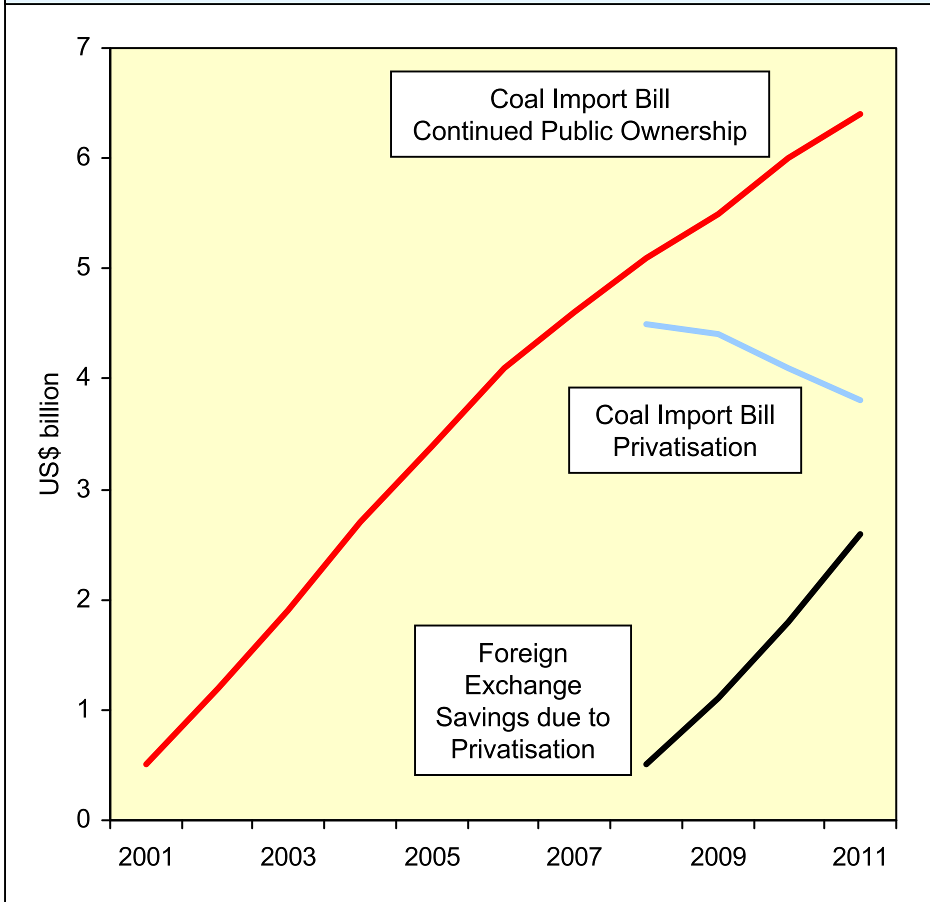


7. Coal Price Scenario

Coal Sector Ownership

- Coal sector privatisation can entail benefits in improved productivity. The privatisation of the coal sector would raise the capital that is needed to stimulate further production. Whether or not this approach is successful depends on other market reforms as well, mainly the price reform of coal and electricity to reflect their true cost of production but also labour reforms, mineral ownership and regulatory reforms to make coal mining more attractive.
- The scenarios that capture the change in the coal sector ownership from public to private will affect the following:
  - coal price at mine mouth: we assumed that this could increase from US$21 to US$25.
  - average production increase from the current 4.5% per year to 10%.
- The gain in foreign exchange due to increased production if privatisation takes place in 2008 is estimated to reach US$2.6 bn in 2011.

FOREIGN EXCHANGE SAVINGS DUE TO INCREASED PRODUCTION - PRIVATISATION SCENARIO



8. Coal Production Profile

Environmental Regulation - Carbon Emissions Control

- Tougher regulations designed to reduce emission control will directly affect coal-burning power plants and consequently could trigger a reduction in coal production. We assumed that this could decrease from an estimated annual growth of 5% (current environmental regulation) to 3% (increased environmental regulation).
- The impact of more stringent environmental regulation will be a continuation of an already existing trend, i.e. to import better quality coal. Imported coal is economically attractive at ports and at locations far from local mines. If the coal production decreases to 3% and the coal supply gap has to be sourced from imports, the foreign exchange bill can increase by US$1.5 bn in 2013. This corresponds to a 29% increase in imports between the two production scenarios.
- A shortage of coal washing facilities for thermal coal, now required for all power plants, exacerbates the environmental problems and the capacity of the coal industry to face more stringent regulation.
- IGCC technology could serve the interests of the coal and power sectors in the context of stringent regulation, i.e. the abundant poor quality local coal could continue to be used in IGCC power plants with the associated environmental benefits brought by this technology..
- Increased environmental regulation will delay project implementation delay and increase project costs in the short-term.

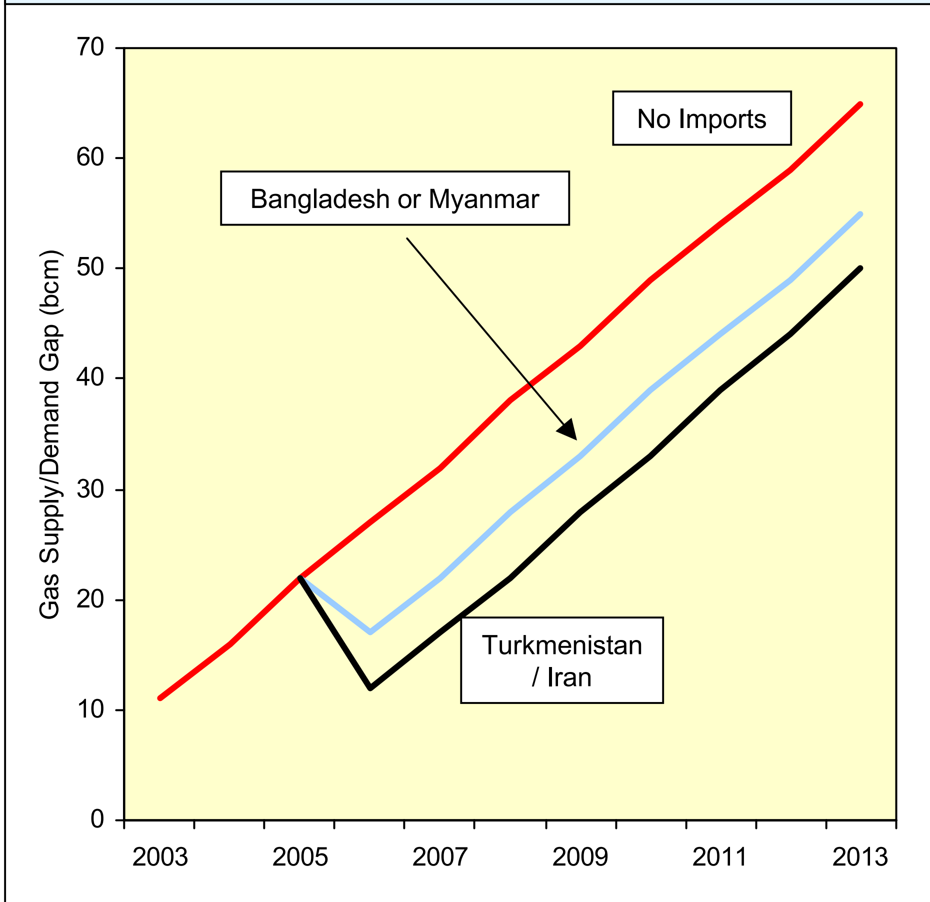
9. Gas Import Options

- Gas import by pipeline could contribute in varying degrees (depending on the size of the pipeline) to meeting forecasted gas demand, as shown in the figure attached.
- The Iran or Turkmenistan pipeline options, as the largest import projects, reduce the supply/ demand gap the most.
- The annual foreign exchange requirements between commissioning (no later than 2006) and 2013 are as follows:
  - Turkmenistan US$1.4bn
  - Bangladesh US$0.6bn
  - Myanmar US$0.9bn
  - Iran US$1.1bn
- The contribution of these import scenarios to meeting anticipated demand decreases over time, considering the estimated demand profile:

Import Scenarios	2006	2013
Iran / Turkmenistan	29%	17%
Bangladesh / Myanmar	19%	11%

GAS PIPELINE IMPORT OPTIONS

Impact on the Gas Supply/Demand Gap



Impact on Energy Security

Energy Supply Scenarios Conclusions

- No matter what scenario is considered (even the recession option) energy imports are needed and will grow significantly if economic growth sufficient to support India's long terms goals is to be achieved.
- Capital requirements needed to support this level of energy imports are significant and need to be addressed by the GOI
- Significant supplies of energy are available regionally to help meet India's needs but regional stability and trade needs to be supported by India
- Improved energy planning is needed to ensure that least-cost options for energy supply and use are developed.

Relevance of the Scenario Analysis to GOI Policy and Programmes. To enhance energy security, GOI policy could include the following options:

1. Oil Sector Policies

a) Promote energy efficiency and use of alternative fuels (e.g., compressed natural gas) in the transportation sector;

b) Continue to seek diversity of supply in oil imports;

c) Establish a strategic oil reserve;

d) Enhance domestic supply by encouraging oil and gas exploration and development to include foreign companies with more realistic exploration PSCs;

e) Develop India's refinery and oil pipeline capacity to ensure that domestic needs are met.

2. Gas Sector Policies

a) Promote development of regional gas infrastructure and trade, both by pipeline and LNG;

b) Support development of India's domestic gas infrastructure, including economically viable power generation off takers.

3. Coal Sector Policies

a) Promote private sector investment to improve operation and quality of coal supplies;

b) Implement pricing reform;

c) Implement appropriate environmental requirements on coal production and use;

d) Improve pricing and operation of the coal transportation sector.

Relevance of the Scenario Analysis to GOI Policy and Programmes (Continued)

4. Power Sector

a) Continue policies to reform and restructure the power sector, including distribution sector reforms;

b) Implement pricing reforms;

c) Continue to support implementation of independent and professional regulatory regimes at the state and centre levels

d) Promote demand-side management and other measures to improve efficiency in energy supply and use;

e) Support energy trade with neighbouring countries (hydro power with Nepal and Bhutan and natural gas and power with Bangladesh)

f) Promote development of renewable energy resources

5. Energy Policy

a) Improve energy sector planning and cooperation among GOI entities;

b) Reduce direct government intervention in the energy sector; and

c) Promote private sector participation and investment.

XIV Summary & Conclusions

Summary & Conclusions

Overall Energy Demand

- The primary energy consumption in India is currently 314 million toe and is projected to increase by 50% over the next ten years. This is driven by high levels of economic growth, albeit from a low base, and a rising population, resulting in higher demand for power and transportation fuels.
- The distribution of primary energy sources is skewed. The eastern region of India accounts for nearly 70% of total coal reserves; the western region has more than 70% of hydrocarbon reserves: More than 70% of the hydro potential of the country is based in the north; and the south is endowed with most of the lignite reserves.
- The overall energy mix may change with the displacement of some liquid fuels by coal and gas in power generation, but the demand for energy is such that India will require all forms of primary energy, oil, gas and coal, as well as other forms such as hydropower, in significantly higher quantities.
- India has insufficient indigenous energy resources to meet future energy needs. Domestic oil and gas resources meet only a fraction of the existing demand and are declining rapidly. There is sufficient coal to meet future demand but this is constrained by limited transportation infrastructure.
- The infrastructure in place to distribute energy around the country is barely adequate, and in some cases is insufficient to meet present needs. There will need to be a major development of infrastructure to meet future demand and ensure security of supply across the country.
- The demand increase will inevitably lead to an increased reliance on imported energy, and a requirement for major investment in infrastructure for transportation and conversion.

Summary & Conclusions

Energy Security

- Energy security consists of managing four different types of risks:

    1. Physical Security of Supply – physical disruptions occur when an energy source is depleted or production is stopped.

    2. Economic Risks - Economic disruptions are caused by erratic fluctuations in the price of energy products in world markets.

    3. Social Risks - The instability of energy supplies, whether linked to erratic fluctuations in prices, relations with producer countries or a chance event may cause serious social disruption.

    4. Environmental Risks - Environmental disruptions may arise through damage to the environment caused by the energy chain whether accidentally or as a result of emissions.

- In assessing and determining policy to ensure energy security it is important to understand that domestic self-reliance is not a security measure and that imports are not a measure of a security problem, indeed diversity and flexibility of supply are the main security issues.

- For India, as with most countries, access to competitive energy will depend upon access to the energy available in the world trading system, and this will increasingly be the case. It is therefore important that India is able to trade freely for global energy resources.

Summary & Conclusions

Oil

- Oil demand in India will be driven by increased transportation requirements for which there are no substitutable fuels in the foreseeable future. The increasing demand will inevitably result in an increased dependency on oil imports as the prospects for improved indigenous oil production are not likely to improve. Global oil reserves are sufficient to supply global demand for many decades into the future. For India, the Middle East will remain the key supply region given its proximity and share of oil reserves.
- For India the major security issue with respect to oil will be one of managing economic risk rather than lack of physical supply. The increasing concentration of oil reserves within the OPEC cartel and the Middle East will increase price volatility and price uncertainty, although overall prices will not rise too high for long periods, as this would bring higher cost non-OPEC oil onto the market.
- There are a number of options open to India to address oil security issues: seek diversity in oil imports; invest in equity stakes in crude oil reserves overseas to provide a natural hedge against volatility; establish a strategic oil reserve to dampen short term volatility; continue to work on the enhancement of domestic supply by encouraging international oil companies to explore in India; manage demand through pricing and fiscal measures to optimise the domestic use of fuel.

Oil Infrastructure

- The projected demand for fuels will lead to a requirement for more/enhanced refining capacity in India. Logistics and security of supply considerations suggest that new refineries should be located in southern and eastern India to match supply with demand.
- A related security issue will be in moving imported supply to demand centres in India via pipelines. Significant investment will be required to direct supplies to demand centres.

Summary & Conclusions

Gas Imports

- Existing indigenous gas supplies are set to diminish as demand for gas accelerates – there is a growing supply - demand imbalance that will need to be met with imports.
- There is sufficient gas in the region to secure long term supplies to India by pipeline and LNG, but both will require large infrastructure investments. Pipeline gas should be more economically advantageous but political aspects will slow pipeline development. Supplies from Iran or Turkmenistan will have to cross Pakistan. Supplies from Bangladesh will have to be sanctioned by a divided Bangladeshi government.
- Although gas project investments, particularly pipelines, will tie India to certain sources of supply with fixed infrastructure, the security risk is relatively low as the economic interests of the seller in these projects are strong. The global history of security in cross border gas projects is extremely good.

Domestic Gas Infrastructure

- There are significant economies of scale in gas infrastructure. Expanding the size of an LNG terminal is much cheaper than developing a new one. However, India should avoid a concentration of gas infrastructure, in order to reduce the impact of any technical disruptions on the supply chain.
- The investment required in gas infrastructure will be massive, and the nature of the gas chain is such that it will be tied to the end use plant. Ultimately the ability to finance local gas infrastructure will depend upon the economic well being of the gas offtaker.

Summary & Conclusions

Coal

- India has substantial coal reserves but has so far been unable to attract additional investment necessary to increase and sustain higher levels of production and improve the quality of the coal. Internationally, reserves of coal are huge, and there is no likelihood of global coal shortages. However the imported sources of high quality coal are relatively limited, Australia and South Africa being the two major potential suppliers.
- In order to increase domestic coal production, the government will need to reform the Indian coal sector to make private sector investment attractive and improve production facilities. Reform of the rail sector to achieve efficient pricing and attract new investment is also required.
- As with gas the security of long term coal imports will be most dependent upon the establishment of transparent energy pricing policies and even handed regulation.
- Imported coal should be allowed to compete with gas for new power generation projects on a level playing field, taking into account the environmental difference between the sources. From a security point of view, coal is more flexible than gas by pipeline and LNG, given that it is a traded commodity.

Coal Infrastructure

- New coal-fired plant will need to be equipped with flue gas desulphurisation or other emission reducing equipment.
- The transportation of coal through the railways will remain constrained due to the huge cost effects of multi layered government involvement in the sector. However the economic pricing of coal transportation will enhance the competitiveness of local coal.

Summary & Conclusions

Power

- At the present time India lacks security of supply in power provision and much of the country suffers power shortages at peak times. The supply shortfall is fundamentally due to long term mismanagement of the power sector which has tended to operate at political discretion rather than on an economic basis. As a result there are large losses, many of the institutions in the sector are insolvent and there has been a lack of adequate investment.
- The primary requirement to establish security of power supply is a radical reform of the power sector to put it on a commercial footing. Economic reform of pricing is a necessary precursor as is restructuring and the introduction of a proper regulatory regime. The removal of the power sector from government favour is critical. The sector needs to become more investor friendly to secure the badly need investment capital. In addition economic pricing will result in more efficient energy use and put downward pressure on demand.
- Demand side management will reduce the need for expensive new capacity additions by shifting load from peak to off-peak through differentiated tariffs, as will improvements in operation of existing plants in increasing the thermal efficiency of a power plant in India from 29% to 35%-42%. This will help to reduce the need for imported fuel.
- The need to have a properly functioning power sector is also critical in ensuring adequate supplies of primary energy. As the major consumer of gas, the power sector is critical in providing the baseload offtake of any gas project. Without commercially viable power sector organisations able to support fuel supply contracts, the development of gas projects will not be possible.

Power Infrastructure

- Interconnections with adjacent power rich states such as Nepal and Bhutan should be encouraged. Nepal has hydroelectricity potential of 80,000 MW and Bhutan 35,000 MW.

Summary & Conclusions

Alternative Energy

- Hydropower potential in India is significant but it will be difficult to raise investment resources. With appropriate screening and environmental assessments it should be possible to develop a limited amount of new hydropower. The most immediate sources of hydropower would be via power imports from from Nepal and Bhutan, as well as long-delayed domestic hydro power projects.
- India's nuclear program is planned to more than double by 2007, when it will reach a total capacity of around 7,600 MW (compared with the current 2,430 MW). Securing finance to develop this source of energy will be difficult, although a major effort world-wide to achieve carbon emission reductions and increased security of supply concerns (related to oil supply) could change this situation.
- Renewable energy is relatively costly and is difficult to fund in a developing country such as India which has many calls on limited supplies of investment capital. The current share of 3% of total power generating capacity (which includes small hydro capacities up to 25 MW) is unlikely to increase significantly over the next ten years despite the interest India has shown for developing these resources. Obstacles to developing these resources are related to insufficient research and development funds required to put some of the technologies on a commercial basis, lack of financing (insufficient domestic capital combined with the low commercial attractiveness of these resources) and lack of policies promoting renewable energy.
- Alternative gas sources such as coal bed methane are commercially unproven and other sources such as gas hydrates do not have established exploitation methods. Therefore, these resources are unlikely to be available to meet India's short or medium term energy requirements. However India should encourage development of alternative gas exploitation via assistance from technologically advanced nations such as the US, which has the resources to undertake the necessary research and development.
- The contribution of alternative energy sources (nuclear, coal bed-methane, hydro and other renewable) to India' s energy needs can be better analysed in the context of a long-term, least-cost planning exercise (not part of the scope for the present study).

Summary & Conclusions

Policy

- India's reliance on imported energy (crude oil and gas) is forecasted to increase. This increase, however, does not represent in itself a measure of the security problem that the country could face due to interrupted supply. Authorities worldwide put a new emphasises on the meaning of security of supply, which has several key dimensions:
  - **Diversification of supply is key** – geographical diversification as well as a balance between various primary energy sources (energy mix). When the sources of primary energy supplies are plentiful and energy suppliers are geographically dispersed, energy security is enhanced. For India this can imply the increased use of natural gas (domestic and imported sources). An increased role for nuclear generation and renewables may begin to surface if the fundamental economics and politics of these energy supply resources changes and available funding increases.
  - **Reliable transpiration of supply** – transportation networks and dependable distribution. The energy gap that India has to meet, a part of which will be sourced from imports, heavily depends on the domestic transportation infrastructure. The critical issue for India is how to finance the needed infrastructure requirements.
  - **Demand side management –** promote energy efficiency as well as use of efficient technologies.
- The role of the government in providing energy security should be to : define an appropriate level of risk; encourage investment and trade; and ensure effective regulation of competitive energy markets.
- India does not have sufficient domestic investment resources to fund the needs of the energy sector over the coming decades. The ability of India to secure the level of investment needed to meet future energy needs will depend very much on the extent to which the government can put the various sub-sectors of the energy sector on an economic footing.
- There are several critical aspects to establishing the energy sector on an economic footing, including: deregulation of prices; opening up access to existing infrastructure; clear rules on the cost of using infrastructure; and transparent regulation of the sector with recourse to internationally acceptable arbitration.

Summary & Conclusions

Planning

- There is an overall lack of co-ordination of the various components of the energy sector in India by government ministries and agencies charged with its oversight (Ministry of Coal, Ministry of Power, Ministry of Petroleum & Natural Gas and Hydrocarbon Directorate). As a result, there is no overall optimisation of energy provision and use. A key to ensuring overall security of energy supply is the optimisation of all energy sources, balancing economic costs against security risks. Given that India will become increasingly reliant upon energy imports and that massive capital investments are required to move these supplies to the markets, there is a need for an integrated and internally consistent framework to ensure that least-cost options are identified and are balanced by appropriate security of supply considerations.